Robot-assisted radical nephrectomy with inferior vena cava tumor thrombectomy: technique and initial outcomes

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BALL MW, GORIN MA, JAYRAM G, PIERORAZIO PM, ALLAF ME. Robot-assisted radical nephrectomy with inferior vena cava tumor thrombectomy: technique and initial outcomes. *Can J Urol* 2015;22(1): 7666-7670.

Introduction: *To describe our technique for robot-assisted radical nephrectomy (RARN) with inferior vena cava (IVC) tumor thrombectomy and to present initial results for our first two patients.*
Materials and methods: *Two patients with renal masses with infrahepatic IVC extension underwent RARN with IVC tumor thrombectomy using a four-arm configuration. Both cases were right-sided tumors. Vascular control was obtained with complete cross-clamping of the vena cava with robotic bulldog clamps. Intraoperative ultrasound was used to delineate extent of tumor extension. Specimens were removed en-bloc, and the IVC was closed with 2-layers of 4-0 Prolene. The specimen is extracted through a lower midline incision.*
Results: *Two robotic IVC thrombectomies were successfully completed. There were no conversions, intraoperative or postoperative complications. Median operative time was 243 minutes with a median estimated blood loss of 150 mL. Both patients were able to ambulate independently free of intravenous opioids on postoperate day 1. Median length of stay was 4.5 (range 3-6) days. Final pathology revealed clear cell RCC in both cases with negative surgical margins.*
Conclusions: *Robotic technology may facilitate RN and IVC thrombectomy in the well selected patient and appears to be a safe and feasible approach.*

Key Words: renal cell carcinoma, tumor thrombus, robotic surgery

Introduction

The use of minimally invasive surgery techniques for the treatment of renal tumors continues to evolve in scope and complexity. Since the first laparoscopic nephrectomy by Clayman et al,[1] the indications for minimally invasive nephrectomy have expanded from simple nephrectomy to include radical nephrectomy (RN) for localized and advanced malignancies and in the cytoreductive setting.[2-4] Compared to open RN, laparoscopic RN results in shorter convalescence and decreased pain with equivalent oncological outcomes.[5,6]

Invasion of the renal vein (RV) and inferior vena cava (IVC) is common in renal cell carcinoma (RCC) with RV or IVC thrombi present in 4% to 10% of renal tumors.[7,8] While case series have demonstrated the feasibility of laparoscopic nephrectomy with IVC thrombectomy, the technique has been slow to gain widespread usage as pure laparoscopic caval reconstruction is a formidable operation, even for the experienced laparoscopist.[9,10]

Robotic technology can facilitate procedures with a reconstructive component, presumably because

Accepted for publication November 2014

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of greater ease of intracorporeal suturing.[9] Indeed, the adoption of robotic technology has led to an increased utilization of minimally invasive partial nephrectomy.[10] This reconstructive ability may allow robotic technology to facilitate a minimally invasive approach to renal tumors with venous involvement. Abaza recently published the first small series of robotic IVC thrombectomies,[11] demonstrating feasibility of the technique.

Our purpose is to describe our technique for robotic IVC thrombectomy, including a novel means of vascular control and to present early outcomes.

Materials and methods

Our institutional IRB-approved prospectively maintained renal mass registry was queried for tumors with IVC thrombi treated from 2003-2013. Robotic IVC thrombectomy was performed in two patients. Both patients had clinically localized disease, and neither received preoperative angioembolization nor neoadjuvant chemotherapy. Both tumors were right-sided. Cross sectional imaging was obtained within 2 weeks of surgery to document tumor thrombus extent. In each case, an alternative approach was planned, with a vascular surgeon on standby and preparation for open conversion and potential venovenous bypass was made.

Patients were placed in the modified flank position. After pneumoperitoneum was established, a 12 mm camera port was placed superior and lateral to the umbilicus. Three robotic ports and two assistant ports were placed.

The robotic procedure mimics the steps of the open approach. The posterior peritoneum is incised, the colon is reflected medially, and the duodenum is Kocherized. The kidney is lifted off of the psoas muscle, and the hilum is identified. The renal artery is dissected and ligated with a GIA stapler. In cases of desmoplastic reaction or prior embolization, the artery may be identified and ligated in the interaortocaval space, though this approach was not utilized in this series.

The fourth arm is used to retract the kidney laterally. The contralateral vein is identified and dissected circumferentially. A vessel loop is placed around the vein, and secured with a *Hem-o-lok clip* (Weck Closure Systems, Research Tri-angle Park, NC, USA) clip to facilitate later identification, as well as placement of a vascular clamp. Next the IVC is dissected circumferentially, removing all lymphovascular and fibroadipose tissue overlying the IVC. Dissection is carried out both laterally and medially, and as the posterior IVC is approached the retrocaval space is visualized directly to identify lumbar veins, which are

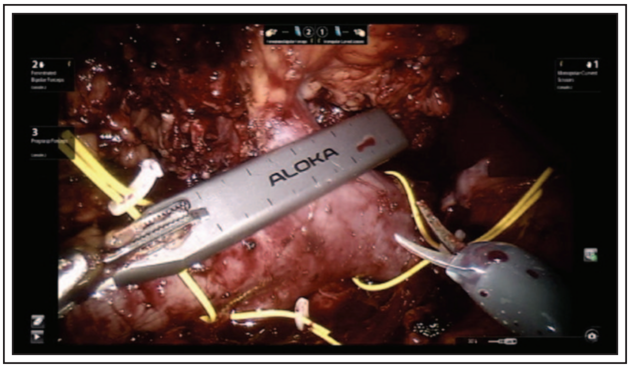

Figure 1. Intraoperative ultrasound is used to delineate cephalad extension of the thrombus.

ligated with *Hem-o-lok* clips. Once the IVC is completely freed posteriorly, the infra-hilar and supra-hilar vena cava are tagged with vessel loops, to atraumatically manipulate the IVC for clamp placement.

Intraoperative ultrasound is used to identify the cephalad extent of the tumor, Figure 1. A robotic probe controlled by the surgeon or a laparoscopic probe directed by the assistant may be used.

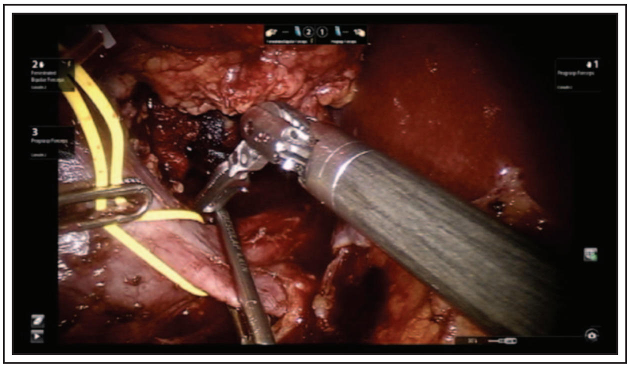

Figure 2. Proximal IVC is clamped with robotic bulldog.

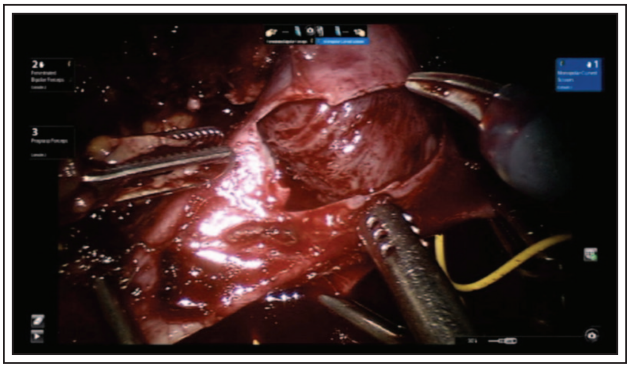

Figure 3. The tumor thrombus is delivered from the IVC.

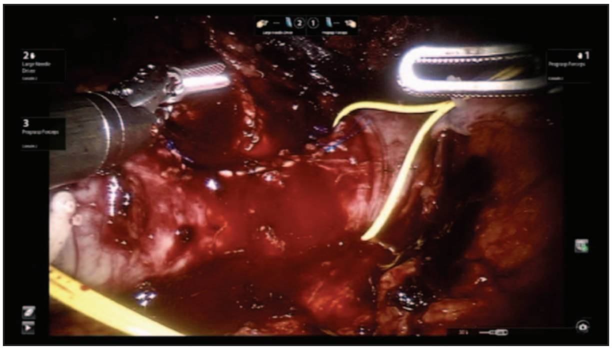

Figure 4. The IVC is closed and hemostatic without significant narrowing.

A test clamp of the IVC is performed to ensure the patient can tolerated cross-clamping. If the patient tolerates cross-clamping, completely vascular control is obtained with robotic bulldog clamps (Scanlan International, St. Paul, MN, USA). The contralateral renal vein, infrahilar IVC and suprahilar IVC are sequentially clamped, Figure 2. Care is taken to ensure the clamp completely occludes the vein.

The IVC is incised over the tumor thrombus using cold dissection. The thrombus is delivered, and the caval lumen is visually inspected to ensure complete resection of the thrombus, Figure 3. The cavotomy is closed with 2 layers of 4-0 polypropylene. Prior to completing the first layer, the lumen may be flushed with heparinized saline and the inferior clamp is flashed to flush air from the caval lumen. A second closure layer is completed and the clamps are removed sequentially beginning with the inferior clamp, followed by the superior clamp and the contralateral vein. This technique results in a hemostatic closure without significant IVC narrowing, Figure 4. Lastly, a hilar lymph dissection performed with removal of all hilar and paracaval fibroadipose tissue.

The specimen is placed in an entrapment bag and extracted through a lower midline incision. The midline incision and all robotic ports are closed in the routine fashion.

Results

A total of two patients underwent robotic radical nephrectomy with IVC thrombectomy. There were no open conversions. Patient demographics and perioperative characteristics are shown in Table 1. There were no intraoperative or postoperative complications. Mean operative time was 243 minutes with a mean estimated blood loss of 150 mL.

TABLE 1. **Patient demographic and perioperative results**

	Patient 1	Patient 2
Age	68	66
ASA	2	3
Body mass index	35.5	23.6
Operative time	270	216
Estimated blood loss	100	200
Pathologic tumor size	9.5	6.6 cm
Lymph node yield	12	5
Fuhrman Grade	III	IV
Stage	pT3bN0Mx	pT3bN0M1

Both patients met discharge criteria by postoperative day 3 and neither patient required ICU admission.

Patient 1 was transitioned to oral pain medication on postoperate day (POD) 1 and discharged on POD3. Patient 2 was diagnosed with a pulmonary embolism preoperatively; therefore, he was admitted preoperatively and placed on intravenous heparin. Postoperatively, the patient was transitioned to oral pain medications on postoperative day 1. Anticoagulation with heparin was restarted and then transition to coumadin. His INR became therapeutic on POD6 and he was discharged that day.

Final pathology demonstrated clear cell RCC in both cases. For patient 1, the tumor was a 9.5 cm Fuhrman grade III clear cell RCC with extensive necrosis and negative surgical margins. Lymph node yield was 12 with all nodes negative for tumor. The adrenal gland was negative for tumor. Pathologic stage was pT3bN0Mx. In patient 2, the tumor was a 6.6 cm Fuhrman grade IV clear cell RCC with negative surgical margins. Lymph node yield was 5 with all nodes negative for tumor. The adrenal gland was found to have metastatic tumor not contiguous with the primary tumor. Pathologic stage was pT3bN0M1.

Postoperatively, there were no complications or readmissions at 90 follow up. With a follow up of 23 months, patient 1 was alive and well with no evidence of recurrent disease. Patient 2 was referred to medical oncology after the discovery of his metastatic disease. He was initiated on pazobinib postoperatively. Unfortunately, he developed metastatic disease to the liver 3 months following surgery and died of disease 6 months following surgery.

Discussion

Although the pure laparoscopic management of an IVC thrombus was first described in 2004,[12] there have been few subsequent reports of minimally invasive IVC tumor thrombectomy and no comparative series. IVC thrombectomy by any approach is a technically challenging operation with the potential for major morbidity and mortality from hemorrhage or embolism. For this reason, any new modality must have a similar safety profile, provide oncologic equivalency and confer some added benefit compared to the gold standard procedure. In the case of open thrombectomy, the approach is often through a thoracoabdominal or chevron incision that can cause significant post-operative pain, delayed convalesce, and can potentially delay adjuvant chemotherapy if it is ultimately required. In the properly selected patient, a minimally invasive approach could improve postoperative recovery. Indeed, rapid convalescence was seen in this cohort compared to historic open cases.

Patient selection is critical before IVC thrombectomy, especially if a minimally invasive approach is employed. Patients must be able to tolerate IVC cross-clamping; therefore, patients who have preload dependent cardiovascular comorbidities are not candidates for this technique as they have a higher chance of requiring venovenous bypass. Additionally, patients must have recent imaging to monitor for thrombus propagation, which could necessitate a change in surgical approach.[13] CT is our preferred imaging modality to detect thrombus as previously reported.[14]

A minimally invasive approach to IVC thrombectomy necessitates expertise with the open procedure both to mimic the technique and in case conversion is needed. In this series, both patients tolerated cross clamping of the cava; however, in patients that cannot tolerate cross-clamping, an alternative strategy must be employed – either partial IVC clamping[13] (if oncologically feasible), or open-conversion and veno-veno bypass. Additionally, experience with minimally invasive dissection of the great vessels, vascular surgical technique, and the resources of an experienced multidisciplinary team is paramount. For example, in cases where the IVC would be significantly narrowed (> 50%) with primary closure consideration for open conversion and grafting may be necessary[15] though robotic patch grafting has been successfully performed.[16]

In the laparoscopic literature, there were no reports of complete IVC cross-clamping. In the only pure laparoscopic IVC thrombectomy reported, the IVC was controlled with a tangentially placed Satinksy clamp that excluded the tumor. In the robotic literature, Abaza reported the first series of robotic IVC thrombectomies, as well as the first instance of minimally invasive IVC cross clamping with either a tangential Satinsky clamp or a modified Rommel tourniquet.[11] In our series, IVC control was obtained by first placing a vessel loop tagged for vessel manipulation, followed by placement of a robotic bulldog clamp. We favor this technique over other reported techniques for several reasons. First, this approach is similar to hilar clamping during robotic partial nephrectomy,[17,18] and may be a more comfortable technique for the experienced robotic surgeon. Second, and more importantly, this technique keeps all robotic clamps internal, while the use of a Satinksy clamp with an external component may be at risk for disruption should an emergent conversion be necessary.

In our series, perioperative outcomes compared favorably with open series[13] and with the robotic series from Abaza,[11] with acceptable operating time, EBL and length of stay. All patients also underwent a lymph node dissection and adrenalectomy. Longer follow up and larger series are required to determine oncologic adequacy of this technique but these early data are encouraging.

Conclusion

Robotic-assisted laparoscopic nephrectomy is a safe technique in well-selected patients with venous involvement. The technique mirrors the steps of the open approach. Careful preoperative assessment is necessary to optimize outcomes and larger comparative series are required to document the ultimate role of this technique in renal oncology. □

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