Curr Urol Rep (2012) 13:190–194
DOI 10.1007/s11934-012-0250-4

Current Status of Robot-Assisted Laparoscopic Ureteral Reimplantation and Reconstruction

Elizabeth A. Phillips · David S. Wang

Published online: 15 April 2012

Abstract We reviewed the literature on robot-assisted laparoscopic ureteral reimplantation and provide general considerations for indications, perioperative management, and steps of the case. Robot-associated laparoscopic procedures are becoming more common in urologic surgery. The uses of the da Vinci robot (Intuitive Surgical, Sunnyvale, CA) are expanding as well. We examine the use of the robot in distal ureteral reconstruction. A PubMed search was performed using keywords "robot" and "ureter," "distal ureter," "ureteral reimplant," "psoas," and "Boari." Papers that discussed proximal ureteral reconstruction and nephroureterectomy were excluded. A total of nine papers were relevant. Personal experience was also drawn upon. Distal ureteral reconstruction using the robotic technique is feasible, safe, and becoming more and more prevalent as surgeon comfort with the robot increases.

Keywords Robot · Distal ureter · Ureteral reimplant · Psoas hitch · Boari flap · Laparoscopy · Devices · Surgery · Endourology · Implantation · Reconstruction · Ureteral stricture · Fistula

Introduction

Since the first laparoscopic nephrectomy in 1991 [1], urology has been advancing rapidly in the field of minimally invasive surgery. Urologists have embraced laparoscopy for its inherent benefits, and this approach has become common in urologic surgery as well as in other surgical subspecialties. Further, with the advent of the da Vinci (Intuitive Surgical, Sunnyvale, CA) surgical system, robotic surgery has become more prevalent as laparoscopic surgery was refined and in many ways enhanced. The explosion of robotic surgery in urology occurred once robot-assisted laparoscopic radical prostatectomy (RALRP) was described. Since that time, robot-assisted surgery has become widely accepted for surgical treatment of a variety of pathology. With surgeon comfort, skill, and experience improving, we are seeing robot-assisted surgery in many other areas within the scope of urology as well as in other surgical fields.

It seems that robotic surgery may have its biggest impact in technically complicated surgeries where fine movements are imperative, anatomic space is limited, and visibility is impeded. In RALRP, the surgeon notes improved visibility and increased ease of performing difficult steps such as nerve dissection and urethral anastomosis. This prompted expansion of the use of the robot to urologic reconstruction, including ureteral reimplant. Ureteral reconstructive surgery is most typically done through an open incision due to the inherent difficulties of performing this operation via traditional laparoscopy. While open reconstruction is still the most prevalent approach for these reconstructions, robot-assisted surgery is a very feasible option. In this article, we describe robot-assisted distal ureteral surgery including ureteral reimplant and modifications of this surgery, including psoas hitch and Boari flap.

General Considerations

With any surgical candidate, one must critically evaluate the patient's feasibility to have successful laparoscopic surgery. Factors affecting this include the patient's age, comorbidities, and body mass index. Surgeons are increasingly undertaking

E. A. Phillips (✉) · D. S. Wang
Department of Urology, Boston University School of Medicine,
725 Albany Street, Suite 3B,
Boston, MA 02118, USA
e-mail: elizabeth.phillips@bmc.org

minimally invasive approaches for elderly patients and those with multiple medical comorbidities with good outcomes. These patients may ultimately benefit more from minimally invasive surgery with shorter operative time, less blood loss, and shorter hospital stay among other outcomes. However, some patients simply are not good laparoscopic surgical candidates.

Morbid obesity is a relative contraindication to laparoscopic surgery, depending on the experience of the surgeon. Obese patients can make laparoscopic surgery very challenging as the body wall inhibits movement of the arms/ instruments. In addition, one must ensure that instruments and trocars are of the appropriate length to gain access to the abdominal cavity and to complete the operation as planned.

In addition, the ideal candidate for laparoscopic surgery is one who has not had significant intra-abdominal surgeries in the past and does not have surgical mesh in place. Prior surgery may impede access to the proper planes and expend excessive time in lysis of adhesions.

Preoperative Evaluation

Preoperative evaluation for patients undergoing distal ureteral surgery may vary depending on the etiology; however, imaging is generally imperative. One needs to define the length, extent, and location of the stricture or pathology. Most patients undergo imaging in the form of computed tomography (CT) urogram because the delayed images are invaluable for preoperative planning of ureteral surgery. Retrograde urogram also may be used to delineate pathology. Tc-mercaptoacetyltriglycine (MAG3) renogram is utilized in some cases to assess and document obstruction. Antegrade imaging through an existing nephrostomy tube can be helpful to define the length and location of the stricture. Concomitant retrograde pyelogram ("up and down-o-gram") also can clearly define the ureteral stricture and aid preoperative planning.

Preoperative Preparation and Positioning

All patients receive a mechanical bowel preparation, usually in the form of magnesium citrate. It is prudent for all patients to undergo preoperative medical clearance by a multidisciplinary team consisting of an internal medicine physician, physician's assistant, or nurse practitioner and an anesthesiologist or nurse anesthetist. Antibiotics should be administered perioperatively in accordance with current recommendations, generally a first-generation cephalosporin or fluoroquinolone antibiotic. All patients have sequential compression devices placed before induction of anesthesia.

Generally, the patient is positioned in dorsal lithotomy and moderate to steep Trendelenburg position, and the robot is brought into location between the patient's legs. Care is taken to pad all pressure points. Hemal et al. [2••] described a slight upward tilt (airplane) on the side of the ureteral pathology. While the authors of this review have not used this positioning, it seems intuitive to elevate the area of interest. Modified positioning is used for operations of the proximal ureter and kidney; however, these will not be discussed here. An orogastric tube is placed before gaining access to the intraperitoneal space to decompress the stomach.

Many surgeons perform cystoscopy and placement of ureteral stents before the abdominal portion of the operation. While some surgeons prefer placement of ureteral catheters in both ureters, it is generally necessary to place a catheter only in the involved ureter. Instrumentation of the contralateral ureter is usually unwarranted.

Our institution has previously reported transurethral use of the Collings' knife to score the mucosa around the affected ureteral orifice to maintain a bladder cuff on the specimen [3]. This is done particularly if a distal ureterectomy is being performed for distal ureteral malignancy. Generally, this is done at the beginning of the case via the transurethral approach. The surgeon incises circumferentially around the ureteral orifice until detrusor fibers are identified; however, full-thickness incision of the ureteral orifice is not performed to prevent leakage of irrigation fluid into the retroperitoneum. During the robotic portion of the procedure, gentle traction on the ureter allows for the entire ureter to be detached from the bladder. Alternatively, cystoscopic excision of the ureteral orifice and bladder cuff can be performed toward the end of the procedure.

Access and Port Placement

Veress needle is utilized to gain access to the intraperitoneal space. This should be done with great care to avoid injury to organs or to the great vessels. This is especially of concern in thin patients.

Port placement proceeds as is diagrammed in Fig. 1, with two 8-mm robotic trocars in a triangular arrangement with the 12-mm robotic camera port at the umbilicus. Placements of 5-mm and 12-mm assistant ports are positioned ipsilateral to the pathology.

Procedure

After gaining access and placement of ports transperitoneally, the colon is swept aside and its peritoneal reflections are transected at the line of Toldt to access the retroperitoneal cavity ipsilateral to the pathology. To our knowledge there have been no reports of pure retroperitoneal distal ureteral surgery; however, this may be feasible for very distal ureteral strictures.

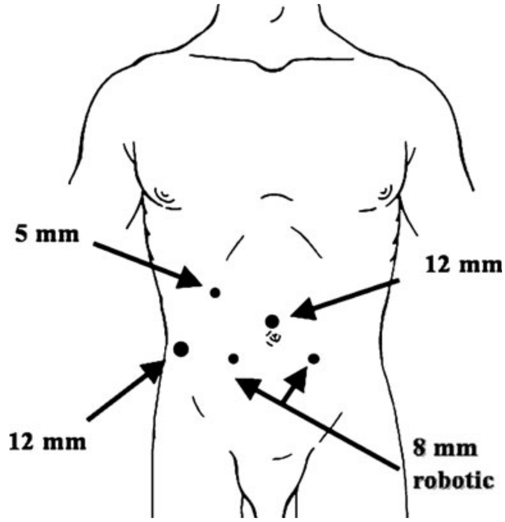

Fig. 1 Port placement for right-sided robotic distal ureterectomy with ureteral reimplant (*From* Uberoi et al. [3], *with permission*)

Glinianski et al. [4] described using a ureteroscope at this point in the operation to identify the area of pathology in the ureter; however, they concede that this can generally be seen as a bulge in the ureteral wall. Dissection of the ureter should be performed so as not to disrupt ureteral blood supply. Transection of the affected portion of the ureter then can be completed using the robotic scissors. This is generally done with a ureteral stent in place, but pulled proximally. If the pathologic area is known or suspected malignancy, care should be taken to prevent tumor spillage and the specimen can be placed in a retrieval bag to be removed later. Spatulation of the ureter is achieved using straight robotic (round tip) scissors.

At this point, dissection of the bladder is completed to allow for adequate mobilization of the bladder on its pedicle. This is imperative for tension-free anastomosis. If tension-free re-anastomosis cannot be completed with complete mobilization, psoas hitch or Boari flap are indicated. Further bladder mobilization can be achieved by freeing the bladder superiorly from the peritoneum as one would do for transperitoneal RALRP. Periodically filling and emptying the bladder via Foley catheter can help determine whether or not sufficient mobilization has been achieved to reach the transected ureter.

Psoas Hitch

When additional coverage is needed than can be attained with mobilization of the bladder and freeing of the ureter, a psoas hitch can be performed. The psoas hitch is conducted by first locating the psoas tendon and clearing off overlying tissue. Vicryl (Ethicon, Inc., Somerville, NJ) suture is placed through the tendon in a longitudinal fashion and through the superior and ipsilateral wall of the bladder. This is tied down in a figure-of-eight fashion. Generally, one or two stitches are sufficient. Often, division of the contralateral bladder pedicle is not necessary.

The bladder is then incised at the site of the new ureteral orifice, which should be medial to the tendon to allow for a ureteral path that is as straight as possible. We prefer to do a running anastomosis with a double-armed Monocryl (Ethicon, Inc.) suture similar to the van Velthoven anastomosis commonly used in RALRP for vesicourethral reanastomosis. Before completion of the anastomosis, the ureteral stent can be pulled distally into the bladder through the ureteral defect.

Boari Flap

In the event that a psoas hitch still leaves the planned anastomosis on tension, a Boari flap may be created. This has been described in the literature by Schimpf et al. [5]. In this case report, they used umbilical tape to measure the distance to be bridged and a rectangular flap was incised from the anterior surface of a moderately filled bladder using electrocautery. Scoring of this incision should be done before incising because measurements and cuts need to be exact. Suturing of the flap, the bladder defect, and the anastomosis then can be completed using Monocryl suture in a running fashion. This is generally performed over a ureteral stent.

Submucosal Tunnel

While it is not always necessary to do so, several surgeons have described techniques for developing a submucosal tunnel in the wall of the bladder so as to create a nonrefluxing ureteral anastomosis. This involves using holding sutures through the anterior bladder wall and suspending the bladder from the anterior abdominal wall during the anastomosis so as to keep the bladder incision gaping. The robotic scissors then are used to create the tunnel. This maneuver is difficult with a pure laparoscopic approach in most cases because it needs to be done at a specific angle to the tissue that often cannot be achieved with rigid instruments. The distal end of the ureter then is pulled through the tunnel on a holding stitch.

Another option, which has been performed in ureteral reimplantation in children, is to incise the bladder down to, but not through, the mucosa and to anastomose the ureter at the most caudal aspect of the incision. The detrusor then is closed over the ureter, in essence, providing the same nonrefluxing ureterovesical junction.

Postoperative Care

Ureteral stents are always left in the ipsilateral ureter postoperatively. A Foley catheter is also left in place routinely. A

Table 1 Indications for distal ureteral surgery

Ureteral transitional cell carcinoma (TCC)
Other neoplasm
Ureteral stricture
Iatrogenic injury
Endometriosis
vesicovaginal or ureterovaginal fistula
Retroperitoneal fibrosis

Jackson-Pratt or Penrose drain is left in the pelvis and brought out via one of the trocar sites. The drain is generally removed on postoperative day 1–2 or when output is low. Routine evaluation of drain fluid for urine leak is not necessary.

The Foley catheter is removed approximately 1 week following the procedure after a cystogram is performed to rule out urine leak. The ureteral stent is removed anywhere from 3 to 8 weeks following surgery, but on average around 4 weeks postoperatively.

Follow-up imaging consists of CT urogram or retrograde pyelogram to assess for resolution of stricture. MAG3 scan is performed to evaluate for obstruction if indicated. Of course, additional follow-up imaging is indicated for ureteral malignancy at fixed intervals.

Complications

The incidence of complications is very low for these operations. As expected, the hospital length of stay and estimated blood loss are lower than that of open surgery. Comparison between laparoscopic and robot-assisted surgery has not been well studied, and series are small due to the few numbers of patients requiring this surgery. Complications are similar to those of any abdominal surgery including hemorrhage and injury to large vessels, infection, ureteral stricture, urine leak, ileus, or other bowel injury, the most common complication being recurrence of the ureteral stricture.

Discussion and Review of Literature

Current literature on this subject is somewhat limited. Since 2007 when case reports were first published regarding robot-assisted ureteral reconstruction, several larger series have been published. The largest series published thus far is a retrospective review of 44 procedures (18 distal ureteral reconstructions) by Hemal et al. [2••]. The largest prospective series to the best of our knowledge is 12 patients from multiple locations in a multinational evaluation by Patil et al. [6].

This surgery has been described by others for the indications listed in Table 1, as well as other indications: vesicovaginal fistula, retrocaval ureter, congenital megaureter, or Hutch diverticulum. Perioperative preparation and management are fairly ubiquitous among series. Procedures have been described much the same across published case reports and series as well. Hemal et al. [2••] reported no use of cystoscopy pre- or postoperatively and preferred instead to place the ureteral catheter intracorporeally in a retrograde and antegrade fashion.

Complication rates stated in the case reports and series reviewed were few (see Table 2). The most common complication reported, as mentioned previously, was recurrence of the stricture at the surgical site. These strictures were managed with balloon dilation as well as chronic stent changes. There also have been reports of hematuria from bleeding at the anastomosis, which was controlled with transurethral fulguration. Injury to the external iliac vein was described by Schimpf

Table 2 Robot-assisted distal ureteral reconstruction

Study	Patients, *n*	Diagnosis	Complications
Yohannes et al. [10]	1	Ureteral stricture	0
De Naeyer et al. [7]	1	Distal ureteral stenosis	0
Mufarrij et al. [11]	4	Ureteral stricture	0
Patil et al. [6]	12	Ureteral stricture (10), Ureterovaginal fistula (2)	0
Laungani et al. [12]	3	Ureterovaginal fistula	0
Schimpf and Wagner [5]	1	Ureteral stricture	0
Glinianski et al. [4]		TCC (Urothelial carcinoma)	1
Williams et al. [9•]	7	Ureteral stricture	1
Schimpf et al. [8•]	11	Ureteral neoplasm (6), bladder diverticulum (2), iatrogenic injury (1), ureteral stricture (1), nonureteral neoplasm (1)	3
Hemal et al. [2••]	18	Ureteral neoplasm (5), ureteral stricture (1), vesicovaginal fistula (2), iatrogenic injury (2), congenital megaureter (8)	1

TCC transitional cell carcinoma

et al. [8•], which was repaired without need for conversion to open operation by oversewing the vessel with Monocryl suture in a figure-of-eight fashion. More serious complications leading to intensive care unit stays or death were described by Hemal et al. [2••] and Glinianski et al. [4]. The latter reported a patient who developed and later succumbed to aspiration pneumonia.

Benefits of robot-assisted surgery have been enumerated on many occasions and they remain the same. One has the benefit of improved dexterity and greater degrees of freedom with jointed arms. Visualization is improved with magnification as well as superior depth perception with three-dimensional picture. Many have commented on ease of suturing with the robot compared to pure laparoscopy and the ergonomic and intuitive movement allowed by the robot. Ability for fine movements is enhanced and tremor is reduced or eliminated. All these advantages make the robot perfectly suited for urologic reconstruction.

Drawbacks of using the robot include higher operative costs, longer set-up time, and loss of tactile feedback, though we anticipate this changing in the near future. Nonetheless, many surgeons have described successful operations of the distal ureter, and robot-assisted laparoscopy is well poised in this arena to have a positive impact for a wide array of ureteral pathology.

Conclusions

The field of laparoscopy is advancing at a fast pace, in large part due to increasing numbers of robot-assisted procedures. Use of the robot for ureteral reconstruction is occurring more and more frequently. While additional investigation comparing outcomes of open versus laparoscopic versus robot-assisted ureteral reconstruction is needed, it seems that patients will likely benefit greatly from surgeon comfort adapting the robot for novel procedures.

Disclosures No potential conflicts of interest relevant to this article were reported.

References

Papers of particular interest, published recently, have been highlighted as:

- • Of importance
- •• Of major importance

1. Clayman RV, Kavoussi LR, Soper NJ, Dierks SM, Meretyk S, Darcy MD, Roemer FD, Pingleton ED, Thomson PG, Long SR. Laparoscopic nephrectomy: initial case report. J Urol. 1991;146(2):278–82.
2. •• Hemal AK, Nayyar R, Gupta NP, Dorairajan LN. Experience with robot assisted laparoscopic surgery for upper and lower benign and malignant ureteral pathologies. Urology. 2010;76 (6):1387–93. Epub 2010 Mar 28. *This report is the largest case series of its type regarding distal ureteral surgery. It nicely outlines a variety of indications for this surgery using this approach*.
3. Uberoi J, Harnisch B, Sethi AS, Babayan RK, Wang DS. Robot-assisted laparoscopic distal ureterectomy and ureteral reimplantation with psoas hitch. J Endourol. 2007;21(4):368–73. discussion 372–3.
4. Glinianski M, Guru KA, Zimmerman G, Mohler J, Kim HL. Robot-assisted ureterectomy and ureteral reconstruction for urothelial carcinoma. J Endourol. 2009;23(1):97–100.
5. Schimpf MO, Wagner JR. Robot-assisted laparoscopic Boari flap ureteral reimplantation. J Endourol. 2008;22(12):2691–4.
6. Patil NN, Mottrie A, Sundaram B, Patel VR. Robotic-assisted laparoscopic ureteral reimplantation with psoas hitch: a multi-institutional, multinational evaluation. Urology. 2008;72(1):47–50.
7. De Naeyer G, Van Migem P, Schatteman P, Carpentier P, Fonteyne E, Mottrie AM. Case report: pure robot-assisted psoas hitch ureteral reimplantation for distal-ureteral stenosis. J Endourol. 2007;21 (6):618–20.
8. • Schimpf MO, Wagner JR. Robot-assisted laparoscopic distal ureteral surgery. JSLS. 2009;13(1):44–9. *The authors have described Boari flap and psoas hitch procedures with the robot in their case series of 11 patients from one institution*.
9. • Williams SK, Leveillee RJ. Expanding the horizons: robot-assisted reconstructive surgery of the distal ureter. J Endourol. 2009;23(3):457–61. *This is a recent publication reviewing the expanding use of the da Vinci system in urologic surgery.*
10. Yohannes P, Chiou RK, Pelinkovic D. Rapid communication: pure robot-assisted laparoscopic ureteral reimplantation for ureteral stricture disease: case report. J Endourol. 2003;17(10):891–3.
11. Mufarrij PW, Shah OD, Berger AD, Stifelman MD. Robotic reconstruction of the upper urinary tract. J Urol. 2007;178(5):2002–5. Epub 2007 Sep 17.
12. Laungani R, Patil N, Krane LS, Hemal AK, Raja S, Bhandari M, Menon M. Robotic-assisted ureterovaginal fistula repair: report of efficacy and feasibility. J Laparoendosc Adv Surg Tech A. 2008;18 (5):731–4.