Chapter 6
Robotic-Assisted Laparoscopic Pyeloplasty

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Abstract: Robotic-assisted laparoscopic pyeloplasty (RALP) is an elegant, minimally invasive reconstructive procedure to treat UPJ obstruction. The technique is discussed here in detail. Some selected patients can be discharged within 18 hours. Some series over five years report success rates of between 95 and 100%. The benefits over laparoscopic pyeloplasty are arguable and need to carefully be measured against the increased cost. Perhaps the main advantages are the ease of ureteric spatulation and suturing due to the EndoWrist instruments.

Keywords: Robotic assisted pyeloplasty, UPJ obstruction, Horseshoe kidney

6.1. Introduction

Ureteropelvic junction (UPJ) obstruction is characterized by obstruction to the flow of urine from the renal pelvis to the upper ureter. Hydronephrosis develops as a consequence and progressive renal impairment may ensue if left uncorrected. Primary UPJ obstruction is a congenital condition and is associated with an aberrant crossing vessel to the lower pole in up to 65% of cases (Sampaio 2000). Patients are often

P. Dasgupta (ed.), *Robotic Urological Surgery in Clinical Practice*,
DOI: 10.1007/978-1-84800-243-2_6,

diagnosed incidentally by ultrasound imaging, though loin pain, hematuria, or urinary tract infection may also be presenting symptoms.

Intravenous urography or isotope diuretic renography are used to confirm the presence of UPJ obstruction. Combining these modalities allows the degree of hydronephrosis, the presence of a high ureteric insertion, the differential function, and the presence of calculi to be ascertained. Contrast CT scanning is useful for detecting aberrant lower pole vessels (see Fig. 6.1).

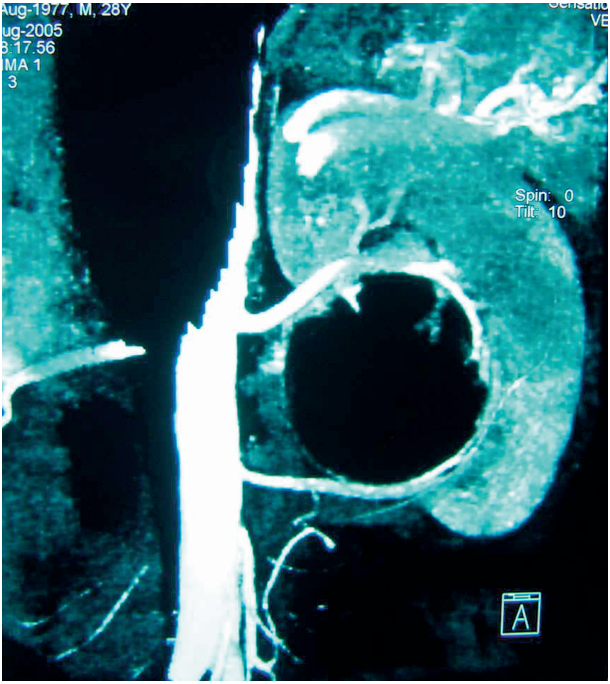

FIGURE 6.1. Contrast-enhanced CT scanning is useful to demonstrate the presence of crossing vessels to the lower pole, a common finding in adult UPJ obstruction.

Progressive loss of renal function or the development of complications such as calculi, are imperative indications for intervention, as is ongoing loin pain.

6.1.1. Management of UPJ Obstruction

A number of minimally invasive techniques have been employed for the management of UPJ obstruction. However, techniques such as antegrade endopyelotomy, retrograde endopyelotomy, and endoscopic balloon dilatation have proved less effective (56–77% success rate) than open pyeloplasty (>90%), which has remained the preferred treatment after many years of experience (Baldwin et al. 2003; O'Reilly et al. 2001; Minervini et al. 2006). In recent years, laparoscopic pyeloplasty has replaced open pyeloplasty in centers where advanced laparoscopic skills are available.

6.1.2. Laparoscopic Pyeloplasty

Laparoscopic pyeloplasty was reported by Schuessler in 1993 (Schuessler et al. 1993). The success rates mirror those of open surgery with 90–95% improvement in clinical and radiologic parameters (Inagaki et al. 2005; Moon et al. 2006). However, dismembered pyeloplasty via the laparoscopic approach remains a challenging procedure for those without considerable laparoscopic experience. Intracorporeal suturing skills are required for reconstruction of the UPJ following resection of the adynamic ureteric segment and reduction of the distended renal pelvis. Even in large series from experienced centers, operating times have remained high, usually due to prolonged anastomotic times (Jarrett et al. 2002). Though no level I or level II evidence exists to justify the superiority of the laparoscopic over the open approach, it appears likely that the benefits to patients of the minimally invasive approach are substantial and that this approach is preferred where available.

6.2. Robotic Technology

The arrival of robotic technology to assist in the performance of complex laparoscopic procedures has had a considerable impact on urologic practice over the past 10years. Robotic-assisted laparoscopic pyeloplasty (RALP) was first performed in a porcine model using the Zeus™ telerobotic system (Computer Motion, California) (Sung et al. 1999). The Zeus™ was a first-generation "master–slave" system which is no longer commercially available. A group of ten pigs were randomized to either conventional laparoscopic pyeloplasty or RALP using the Zeus™ system. This pilot study concluded that RALP was feasible though no particular advantages were observed with the robotic-assisted approach. Though other reports of RALP using the Zeus™ system have been published (Luke et al. 2004; Lorincz et al. 2005), the surgical robotics market is now dominated by the da Vinci™ surgical system (Intuitive Surgical, California) and the remainder of this chapter relates to the use of this system for RALP.

6.2.1. Advantages and Disadvantages of Robotic Technology

The da Vinci™ surgical system offers a number of technical advances which might be useful in the performance of laparoscopic pyeloplasty. These include:

- Improved depth perception with 3D vision.
- Up to 10x magnification.
- Motion scaling—this allows greater precision when carrying out fine movements.
- Improved degrees-of-freedom using EndoWrist™ technology—this reduces the difficulty associated with complex laparoscopic suturing.
- Articulating EndoWrist™ scissors—this functions as a Potts-type scissors, allowing easy spatulation of the dismembered ureter.

The combined benefit of these features is to reduce the difficulty associated with certain steps of laparoscopic dismembered pyeloplasty.

However, the current generation of robotic technology has a number of disadvantages, including:

- Lack of haptic feedback.
- Bulky robotic arms which may lead to clashing during laparoscopic renal surgery.
- Expensive.

6.3. Technique of RALP

Under general anesthesia and following the administration of prophylactic antibiotics, the patient is placed in the lithotomy position. A cystoscopy is performed and a double-J ureteric stent is placed following a retrograde ureteropyelogram. A urethral catheter is left in the bladder. The patient is then repositioned in a 60° lateral decubitus position with the operating table flexed to its maximum extent (Fig. 6.2). A kidney rest is not routinely used. Care is taken to protect all pressure points.

A four-port transperitoneal approach is used (Fig. 6.3). Pneumoperitoneum is established using a Hasson port in the mid-clavicular line, lateral to the umbilicus. Insufflation pressure is set at 12 mmHg. Two further 8-mm da Vinci™ ports are placed in the iliac fossa and in the hypochondrium, triangulating with the camera port. Though the 12-mm assistant port is often placed laterally during conventional laparoscopic pyeloplasty, the presence of the robotic cart means that this port is more user-friendly when placed in the upper midline (Fig. 6.4)

The 30° down-angle lens is most useful at this stage of the procedure, though the 0° lens may be used later when suturing. The colon is mobilized and the ureter and lower pole of kidney identified. Our preferred instruments at this stage of the procedure are EndoWrist™ bipolar graspers on the left and EndoWrist™ monopolar scissors on the right. The assistant uses a Johannes fenestrated grasper. The UPJ is

FIGURE 6.2. Patient position for right robotic-assisted laparoscopic pyeloplasty.

fully mobilized and any crossing vessels noted and preserved (Fig. 6.5). The ureter is divided below the UPJ and the renal pelvis is transected and reduced. The adynamic segment is removed. Spatulation of the ureter on its posterior-lateral aspect is accomplished without much difficulty using the angulation on the EndoWrist™ scissors.

We prefer to complete the anterior wall of the anastomosis first rather than the posterior wall. The UPJ is reconstructed (anterior to any crossing vessels) using EndoWrist™ large needle holders as follows.

- A 15-cm 3–0 Vicryl™ stay suture is placed between the apex of the spatulated ureter and the dependent part of the renal pelvis.
- A 20-cm 3–0 Vicryl™ suture is used to complete a running anastomosis along the anterior wall of the reconstructed UPJ. This suture is locked when it reaches the upper limit of the anterior ureteropelvic anastomosis.

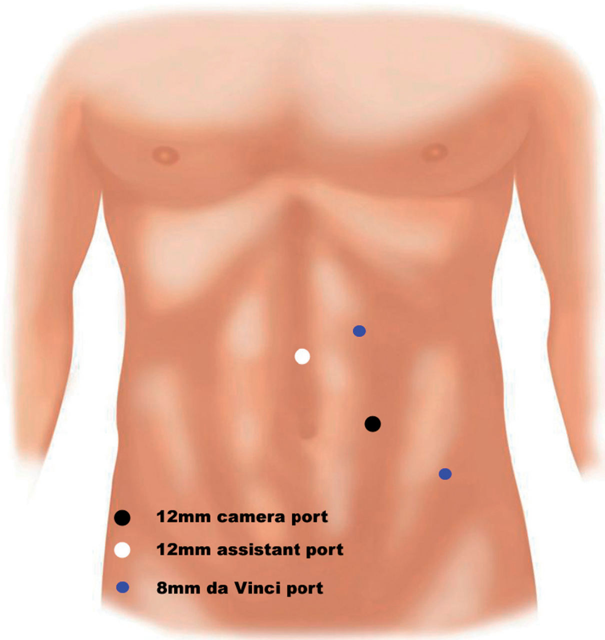

FIGURE 6.3. Port configuration for robotic-assisted left laparoscopic pyeloplasty. A mirror-image configuration is used for right-sided procedures.

- A further 20-cm 3–0 suture is used to close the pyelotomy above the ureteropelvic anastomosis. This running suture is started at the superior aspect of the opened renal pelvis and is secured to the suture which has been locked at the upper end of the anterior anastomotic suture.
- The double-J stent is now replaced in the renal pelvis.
- The posterior edge of the ureteropelvic anastomosis is now closed with a further 3–0 Vicryl™ running suture.

The final appearance demonstrates the reconstructed UPJ anterior to the crossing vessels (Fig. 6.6). A nonsuction tube drain is placed through the lateral 8-mm port and the wounds

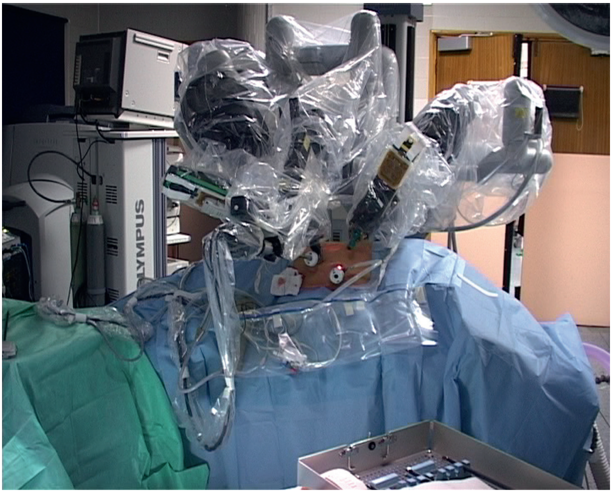

FIGURE 6.4. da Vinci™ cart docked for right robotic-assisted laparoscopic pyeloplasty.

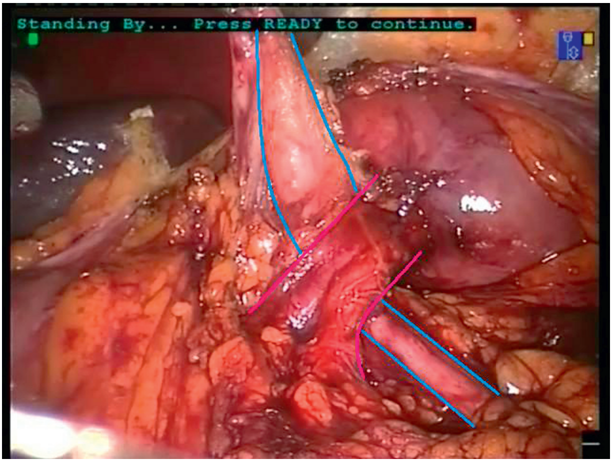

FIGURE 6.5. Aberrant vessels crossing anterior to the left UPJ.

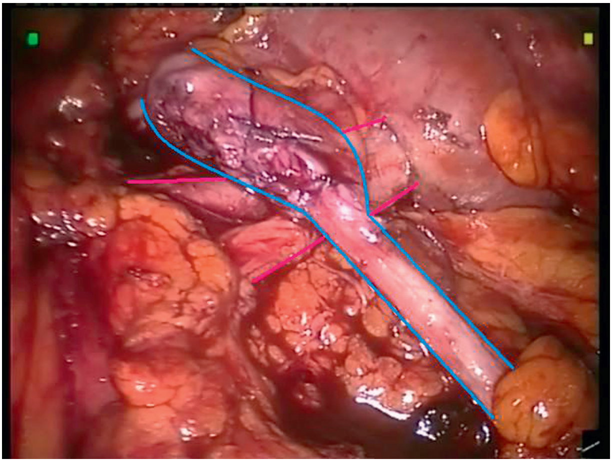

FIGURE 6.6. Appearance post-robotic-assisted laparoscopic left pyeloplasty. The UPJ has been transposed anterior to the crossing vessels.

are closed. Patients are usually discharged within 24 hours and the urethral catheter and drain removed within 3–5 days in the out-patient setting. The double-J stent is removed 6 weeks postoperatively.

6.4. Results of RALP

By the end of 2007, over 200 cases of RALP had been published in the world literature. Some of these series are summarized in Table 6.1.

Gettmann et al. reported their first experience in 2002 following RALP in nine patients (Gettman et al. 2002a). Using a four-port transperitoneal dismembered technique, they reported a mean operating time of 139 (80–215) min, with a mean anastomotic time of 62.4 (40–115) min. One patient required subsequent open surgery to repair a defect

TABLE 6.1. Published series of robotic-assisted laparoscopic pyeloplasty using the da Vinci™ surgical system

Author	N=	Operative time (min)	Suturing time (min)	Complications	Success rate (%)	Follow-up (months)
Bentas	11	197 (110–310)	N/A	None	100	12 (12–27)
Murphy	15	187 (115–240)	47 (27–65)	None	93.3	9 (1–19)
Patel	50	122 (60–330)	22 (10–100)	None	100	11.7 (1–28)
Schwentner	92	108 (72–215)	24.8 (10–115)	5% reoperation rate	96.7	39.1 (3–73)

in the renal pelvis. A 100% success rate was reported but with very limited follow-up (mean of 4.7 months).

Bentas et al. reported their early experience of 11 cases of RALP in 2003 (Bentas et al. 2003). A transperitoneal dismembered technique was used in all cases. They reported a mean operative time of 197 (110–310) min with no intraoperative complications, minimal blood loss, and a 100% success rate at 1 year. It is noteworthy that these authors had no previous experience of laparoscopic pyeloplasty.

We published our own experience of 15 RALP when reporting our overall experience with robotic-assisted laparoscopic renal surgery (Murphy et al. 2008). This group included six pediatric and nine adult patients. The mean operative time was 187 (115–240) min with a mean suturing time of 47 (27–65) min. We noted in particular that the suturing time reduced considerably over the most recent five cases, averaging less than 30 min. One patient was lost to follow-up but the remaining 14 patients had excellent clinical and radiologic outcomes at a mean follow-up of 9 (1–19) months. Our series also featured three patients who were discharged within 18 hours of RALP, highlighting the minimally invasive nature of this procedure.

Patel et al. reported the outcomes of 50 dismembered RALP (Patel 2005). The operative time averaged 122 (60–330) min with a mean anastomotic time of only 20 (10–100) min. There were no reported complications. At a mean follow-up of 11.7 (1–28) months all 50 patients were doing well clinically and radiologically.

The largest reported series at this time is that of Schwentner et al. (Schwentner et al. 2007). This group updated the results of Gettmann (Gettman et al. 2002a) and others (Peschel et al. 2004) who had reported the early RALP results from Innsbruck. With a mean follow-up of 39.1(3–73) months, they reported their series of 92 patients who had undergone dismembered RALP over a 5-year period. Crossing vessels were noted in 45 patients. The mean operating time was 108 (72–215) min though this had reduced considerably as their experience developed. The last 12 cases had a mean operating time of 89 (72–112) min. The overall mean anastomotic time was 24.8 (10–115) min. An antegrade approach was used to place the double-J stent intraoperatively in 87 patients. Malposition of the stent led to ureteroscopy in three patients. Three other patients required early operative reintervention. This included two patients who hemorrhaged into the collecting system, one of which required percutaneous nephrostomy and stent exchange and one of which required redo-open pyeloplasty at 3 months. The third patient had a urine leak and required open exploration to close a large defect in the renal pelvis. The overall success rate was 96.7%.

6.4.1. Conventional vs. Robotic-Assisted Laparoscopic Pyeloplasty

Conflicting conclusions are drawn from two studies which have sought to compare RALP with standard laparoscopic pyeloplasty. In a nonrandomized comparison, Gettman's group reported shorter operative and anastomotic times with RALP compared to pure laparoscopic pyeloplasty (Gettman et al. 2002b). The total operative and suturing times were 140 and 70 min compared to 235 and 120 min for robotic and laparoscopic pyeloplasty, respectively. However, Kavoussi's group have reported longer operating times and significantly higher costs associated with the robotic approach in a small comparative trial ($n = 20$) (Link et al. 2006). Operative costs were 2.7-times higher in the robotic group (1.7-times if the capital costs were excluded). There are no randomized trials to compare the conventional and robotic-assisted laparoscopic approaches.

6.4.2. RALP in Special Situations

Two of the more challenging situations when considering pyeloplasty are the presence of a horseshoe kidney, and previous failed treatment of UPJ obstruction (secondary

UPJ obstruction). RALP has been reported for both situations. Chammas et al. reported their RALP experience with three horseshoe kidneys using the da Vinci™ surgical system (Chammas et al. 2006). A transperitoneal 4-port approach was used. The isthmus was not divided. The mean operating time was 148 (125–170) min with minimal blood loss. The only reported complication was an episode of pyelonephritis which responded well to antibiotics. With a mean follow-up of 21 (13–29) months, all three patients had good clinical and radiologic outcomes.

The series from Innsbruck includes two patients with horseshoe kidneys (Schwentner et al. 2007). The isthmus was divided in both cases using monopolar cautery, sutures, and a bolster as necessary. The lower pole on each side was nephropexed to the psoas to ensure a straight reconstructed UPJ with no kinking. Both patients had an uneventful recovery with good outcomes.

Our own experience at Guy's includes dismembered pyeloplasties for two horseshoe kidneys. The isthmus was not divided in either case. Operative time averaged 170 min with no significant complications. Both patients had satisfactory outcomes. There is frequently complex vascular anatomy in these cases, often with branches from the common iliac artery. We adjust our port positions to have the camera port at the umbilicus and the remaining ports placed more caudal than described above.

Secondary UPJ obstruction presents a challenging situation. Schwentner's large series of 92 patients includes 12 who had previous intervention for UPJ obstruction (Schwentner et al. 2007). Of these, three had undergone previous nondismembered pyeloplasty and nine had undergone endopyelotomy. One of these 12 patients required early open reoperation to close a defect in the renal pelvis and subsequently made a good recovery with no long-term sequelae. The remaining 11 patients underwent uncomplicated RALP with a good outcome.

Patel's series of 50 patients included five who had undergone previous intervention for UPJ obstruction (Patel 2005).

Of these, three had undergone pyeloplasty and two had undergone endopyelotomy. No complications were reported for this sub-group and they form part of a series with a 100% overall success rate.

6.5. Conclusions

It is apparent that the da Vinci^{TM} surgical system is a useful tool for laparoscopic dismembered pyeloplasty. The additional degrees-of-freedom are not only useful for the reconstructive aspect of this procedure, but also for the mobilization of the renal pelvis especially when crossing vessels are present. The additional angulation provided by the robotic instruments facilitates prompt progression throughout the dissection. The benefits of wristed instruments for laparoscopic suturing are well recognized and are particularly useful when complex reconstruction is required such as in dismembered pyeloplasty.

The available data suggests that RALP is feasible and safe, and produces clinical outcomes comparable to those of laparoscopic and open pyeloplasty. There is clearly a health economic issue regarding the funding of this expensive technology, but the likely reduction in learning curve for surgeons, and in recuperation time for patients, may help offset the investment. Further developments in the field of surgical robotics will hopefully lead to more affordable, less bulky equipment with the addition of haptic feedback to mimic tactile sensation.

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http://www.springer.com/978-1-84800-242-5

Urologic Robotic Surgery in Clinical Practice
Dasgupta, P. (Ed.)
2008, XIV, 250 p. 88 illus., 40 illus. in color., Softcover
ISBN: 978-1-84800-242-5