Robot-assisted pyeloplasty: review of the current literature, technique and outcome

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Aim: *To review the global select data on the current technique, perioperative outcome and literature on the robot-assisted pyeloplasty (RAP).*

Methods: *The published English literature (PubMed) was extensively searched using the key words; robot, robot-assisted pyeloplasty, laparoscopy, laparoscopic pyeloplasty and ureteropelvic junction obstruction. The selected studies were then reviewed, tracked and analyzed in order to determine the current role, outcome and status of robot-assisted laparoscopic pyeloplasty.*

Results: *The search yielded about 25 published series on RAP comprising about 740 cases with a mean operative time, estimated blood loss, crossing vessel prevalence, hospital stay,perioperative complication rate and follow up duration of 194 min, 50 mL, 47%, 2.3 days, 6% and 14.9 months respectively.*

Conclusion: *The initial peri-operative results and intermediate follow up of cases of repair of the ureteropelvic junction obstruction with robot-assisted pyeloplasty appear to be favorable and comparable to that of open pyeloplasty, while long term outcome data is still awaited. The da Vinci surgical robotic system is a promising surgical armamentarium in the hands of the modern day urologist for the minimally invasive definitive surgical management of both primary and secondary ureteropelvic junction obstruction.*

Key Words: laparoscopy, robot-assisted pyeloplasty, laparoscopic pyeloplasty and ureteropelvic junction obstruction, robot

Introduction

Historically the first reconstructive procedure for ureteropelvic junction (UPJ) obstruction was performed by Trendelenburg in 1886.[1] Traditionally open surgical pyeloplasty has been plagued by morbidity due to significant postoperative pain mainly on account of the flank incision and delayed convalescence. In an effort to overcome many of these disadvantages of traditional open surgical pyeloplasty other minimally invasive surgical options such as endopyelotomy, endopyeloplasty and laparoscopic pyeloplasty (LP) came in to existence. However the former two procedures appeared to have lower success rates especially with regards to long term patency of the UPJ as compared to definitive surgical pyeloplasty. Open surgical pyeloplasty via retroperitoneal access has generally been traditionally viewed by the majority as the reference standard for managing ureteropelvic junction obstruction (UPJO), the reported success rates of which are known to exceed 90%.[2] With the worldwide adoption of minimally invasive access surgery; endopyelotomy LP came in to vogue for managing UPJO. Dismembered laparoscopic pyeloplasty (DLP) was first described and reported in the published English literature in 1993 by Schuessler and coworkers.[3] In the same year Kavoussi et al[4] and later Janetshek et al,[5] in 1994 also confirmed the safety and efficacy of laparoscopic pyeloplasty. Subsequently the results of laparoscopic pyeloplasty (LP) were found to be comparable to open surgery by others workers.[6-8] This prompted some to rename LP as the new reference standard for managing UPJO.[9] The advantages of LP include shorter convalescence, reduced pain, briefer hospital stays, superior cosmesis, with success rates exceeding 90%. LP has traditionally been confined to the domain of high volume centers of excellence with skilled laparoscopic surgeons.[10] The main drawback of LP is the relative difficulty of performing intracorporeal suturing that demands

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significant training and expertise. However with the emergence of robot assistance in laparoscopic urology, the da Vinci robotic system with its three-dimensional vision, tremor filtering, Endowrist system with six degrees of freedom, reconstructive surgery and intracorporeal suturing has now become technically easier.[11-13] Initial cases of robot-assisted pyeloplasty (RAP) were reported by Graham;[14] Guilloneau[15] and Gettman and colleagues.[12] Subsequently other workers successfully reported larger series of RAP, see Table 1.

TABLE 1. **Salient features of selected worldwide reported series of robot-assisted pyeloplasty**

Author/ref	N	T/P-R/P	Mean ORT (CT) ST*	EBL	CV (%)	HS (d)	Complications	Follow up (mth)
Gupta et al[16]	24	T/P (TM)	125 ± 24, 44 ± 15*	38.7	-	2.5	1(PD)	12
Kaouk et al[24]	4 (1°), (2°) 6	R/P	175	50	3 (30)	2	Nil	30 (24-36)
Yanke et al[25]	29 (1°)	T/P	-	-	20 (69)	-	Nil	19 (13-25)
Murphy et al[26]	15 (1°)	T/P	187	30	9 (44)	2.2	Nil	-
Mufarrij et al[27]	117 (1°)	T/P	217 (80-510)	58 (10-600)	62 (53)	2.1 (0.8-7)	9 (M); 4 (m)-11%	30 (3-63)
	23 (2°)	T/P	216 (110-345)	68 (10-300)	15 (65.2)	2.1(1-3)	1(M)-4.2%	24 (5-51)
Hemal et al[28]	9 (2°)	T/P	106 (95-150)	72.4 (40-200)	2 (22)	3.4 (2-5)	Nil	7.4 (2-15)
Schwenter et al[29]	80 (1°), 12 (2°)	T/P	108.3 (72-215)	< 50	45 (48.9)	4.6 (3-11)	3 (m)-3.2%	39.1
Olsen et al[30]	67 (1°)	R/P	146 (92-300)	-	15 (22.4)	1.5 (1-6)	11 (m)-16.4%	12 (0.9-49)
Lee et al[31]	33 (1°)	R/P	219 (133-401)	3(0-50)	11 (33.3)	2.3 (0.5-6)	1-3%	10
Weise et al[32]	31 (1°)	T/P	271 (76)	< 100	23 (74)	2 (1-3)	Nil	10 (1-31)
Yee et al[33]	8 (1°)	T/P	363 (255-522)	13.1	-	2.4	1 (M), 1 (m)-25%	14.7
Kutikov et al[34]	9 (1°)	T/P	123	-	0	1.4	Nil	-
Patel et al[35]	50 (1°)	R/P	122 (60-330)	40	30	1.1	-	11.7
Palese et al[36]	35 (1°)	T/P	216.4 ± 52.9	73.9 ± 58.3	10 (28.6)	2.89	1 (M)-2.8%	7.9
Palese et al[37]	38 (1°)	T/P	225.6 ± 59.3 64.2 ± 14.6*	77.3 ± 55.3	10 (26.3)	2.9 (1-13)	1 (M),3 (m)-10.5%	12.2
Atug et al[38]	7 (1°)	T/P	184 (165-204) 39.5 (30-46)*	31.4 (10-50)	-	-	PD:2	10.9 (2-18)
Siddiq et al[39]	26-4 (2°)	T/P	245	69		2	2-7.7%	6
Atug et al[19]	8 (1°)	T/P	275.8 (180-345)	48.6 (10-100)	2 (25)	1.1 (1-2)	Nil	12.3 (4-22)
Atug et al[40]	37 (1°)	T/P	219.4 (130-345)	49.5 (10-200)	16 (43%)	1.1 (1-2)	Nil	13.5 (3-29)
	7 (2°)	T/P	279.8 (230-414)	52.5 (20-100)	2 (28%)	1.2 (1-3)	Nil	10.7 (3-20)
Mendez-Torres et al[41]	32 (1°)	T/P	300 (120-510)	52	14 (44)	1.1(1-3)	2 (m)-6.25%	8.6 (1.5-16)
Bernie et al[42]	7 (1°)	T/P	324	60 (50-100)	4 (57)	2.5 (2-6)	2 (m)-28.5%	10 (5-15)
Bentas et al[43]	11 (1°)	T/P	196 (110-310)	50	-	5.5 (2-9)	1-9%	21 (11-27)
Gettman et al[12]	6 (1°)	T/P	140 (80-215)	< 50	-	4	(0) Nil	-
Gettman et al[13]	7 (1°)	T/P	138.8 (80-215)	< 50	-	4.7 (4-11)	1(M)-11%	4.1 (1-8)
	2 (2°)	T/P	62.4 (40-115)*					
MEAN	740	-	194	50	45	2.35	6.0	14.9

Most figures are rounded of to the nearest decimal. 1°/2° = primary or secondary UPJ obstruction;
R/P = retroperitoneoscopic; T/P = transperitoneal; TM = transmesocolic; *ST = suture time; M = major; m = minor

Surgical technique of robot-assisted pyeloplasty (RAP)

Clinical assessment

The diagnosis of UPJO is suspected clinically, that is subsequently confirmed by imaging studies. This helps in the detection of coexisting pathologies such as renal stones, crossing vessels, and megaureter. Preoperative assessment of the UPJO with uclear renography is performed in order to obtain definitive assessment of UPJO and to confirm the diagnosis of significant renal outflow tract obstruction. It also provides a baseline quantification of the preoperative renal function for subsequent follow up.

Indications

Symptomatic patients with evidence of significant renal outflow tract obstruction as confirmed by serial renography and or clinical worsening of obstructive hydronephrosis are the candidates that are most likely in need of some form of pyeloplasty. Patients with large baggy pelvis may in addition need a reduction pyeloplasty in order to ensure dependent drainage. Patients with equivocal UPJO may be observed and followed up with serial nuclear scans.

Contraindications

Patients with prior major intraabdominal surgery/ laparotomy should be excluded from a transperitoneal laparoscopic/robotic procedure. Patients of UPJO with extensive comorbidity on account of general medical problems and or cardiopulmonary insufficiency are those in whom a laparoscopic procedure may serve to be a relative contraindication due to exaggerated risks of hypercarbia.

Preoperative preparation

The type of repair needed is dependent on the size of the pelvis, length of the UPJ stricture, presence of a crossing vessel and the degree of renal function. Sterile urine cultures must be obtained prior to surgery. Preoperatively patients are advised a clear liquid diet for 24 hours and a rectal suppository on the night prior to surgery. The procedure is performed under general anesthesia and prophylactic antibiotics. In confirmed cases the preplacement of a JJ ureteral stent is not necessary, in case any difficulty in locating the UPJ, intravenous 20 mg of furosemide may be administered in order to distend the renal pelvis and facilitate its identification during surgery. The robot is sterile draped and the console camera is recalibrated prior to initiating the procedure.

Position

A Foley catheter is placed and clamped so as to facilitate subsequent antegrade JJ stenting. The patient is positioned with the operative kidney facing upwards in the kidney/flank position at an angle of 45^{o} over a supplemental kidney bridge and an axillary roll over a flexed operating table (lateral decubitus position) with back supports. The patient is secured by strapping with a wide surgical tape over a foam pad both at the level of the ipsilateral chest/shoulder and as well as at the level of the thigh along with the anti-embolic pneumatic leg bags. Adequate care is taken to pad all the pressure points. The ipsilateral arm is fixed to another arm board rest that is securely taped to the armrest over a foam pad in a manner so as to facilitate free movement of the robotic arms.

Surgical approach

RAP may be via (i) trans-peritoneal or (ii) retroperitoneal access.

(i) Transperitoneal approach is generally the preferred approach. This allows clear visualization of all the anatomical structures with adequate space for optimal access and positioning of the robotic and assistant ports. It is also the preferred approach to repair of UPJO associated with the pelvic ectopic kidney or a horseshoe kidney. Transperitoneal access may be used for a RAP via the transmesocolic approach that has also been previously described by these authors elsewhere[16] or by the classical colonic mobilization approach to the UPJ. The transmesocolic approach has the advantage of doing away with colonic mobilization, providing the most direct approach to the UPJ after incising the mesocolon through the relatively avascular transmesocolic window, precluding extensive renal mobilization. It is considered to be a safe, feasible and a highly effective technique in patients with a large prominent hydronephrotic pelvis underlying a thin mesentery.[16] The use of the transmesocolic approach is generally restricted to a leftsided UPJO, because anatomically the left colic flexure lies superior to the right colic flexure and the left UPJ lies beneath the left colonic mesentery. This approach should be avoided in patients with a high BMI and a thick mesentery. Retrocolic access with mobilization of the colon to approach the UPJ is preferred by us in cases of UPJO associated in the right kidney, with morbid obesity, concomitant renal calculi, accessory renal vessels, retrocaval ureter and or prior renal surgery where renal mobilization would be needed.

(ii) Retroperitoneal laparoscopic approach to the UPJ, may be preferred in patients with prior repetitive intraperitoneal surgery where postoperative

adhesions may preclude a safe laparoscopic/robotic intraperitoneal access. Retroperitoneoscopic surgery has the advantage of offering direct early surgical access to the UPJ and in case of any leak or infection the urinoma is contained within the retroperitoneum. The disadvantages of retroperitoneal access include lack of space and technical difficulty in intracorporeal suturing due to instrument/port collision/overcrowding. The retrocaval ureter may also be successfully repaired via this approach.

Port placement

Figure 1 shows the port placement that has been used by others and these authors for a transmesocolic approach. Pneumoperitoneum is established by a Veress needle at a point just outside the lateral border of the rectus muscle above the umbilicus. The Veress needle is removed, and the stab incision is extended for placement of a 12 mm camera port. The camera is then introduced and the abdomen is inspected for any intraabdominal injury. Two working 8 mm robotic ports are also inserted under vision in the ipsilateral midclavicular line on either side of the camera port. In order to avoid any instrument collision between the robotic arms a working distance of about 7 cm-8 cm is maintained with an obtuse docking angle and triangulation of the instruments. One or two additional 5 mm ports are also inserted infraumbilically either in the midline or contralateral side for retraction, suction, and suture handling. Alternatively with the four arm robot (Prograsp), the fourth robotic trocar may substitute for the additional trocar. After placing the trocars the robot is securely positioned and docked from the back of the patient.

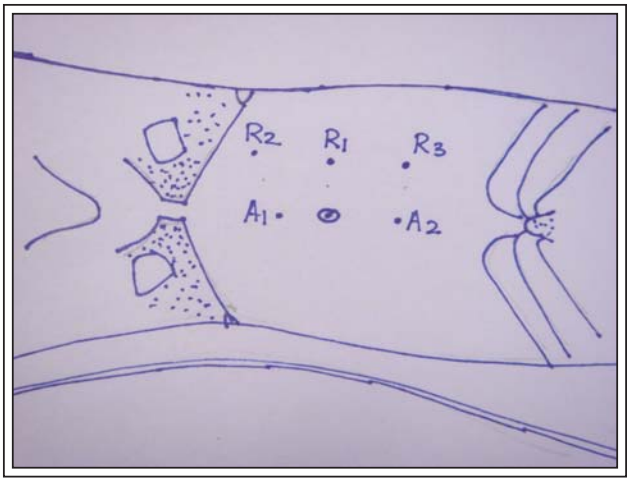

Figure 1. Arrangement and placement of the ports used in robot-assisted laparoscopic pyeloplasty. R1 represents the primary 12 mm camera port, R2, R3 depict the 8 mm left and right working robotic ports. A1 and A2 depict the 12 mm and 5 mm assistant ports.

For a robot-assisted retroperitoneoscopic pyeloplasty: A spherical retroperitoneal balloon trocar system is used to develop the retroperitoneal space through a small stab incision made just below and lateral to the tip of the 12th rib through which a Hasson's convertible trocar is inserted (this serves as the primary 12 mm robotic camera port). The left and right 8 mm robotic ports are inserted at the costovertebral angle and at the superior aspect of the iliac crest respectively with an assistant 5 mm suction port placed 5 cm inferior to the camera port.

Robot-assisted pyeloplasty

The robotic surgical system arms are positioned behind the patient at an angle of 30° cephalad. The robot is docked. If the pelvis is grossly hydronephrotic, a transmesocolic approach is used to expose the pelvis. The basic surgical steps are mimicry of open surgery. The principles followed are (i) preservation of crossing vessels, (ii) dismembering the UPJO and excising the narrow portion, (iii) spatulating the ureter medially, (iv) subtracting the dilated pelvis, (v) creating a tension free water tight dependent anastomosis.

In the transmesocolic RAP, the robotic monopolar scissors is used to make an incision, parallel to the mesenteric vessels, through a relatively avascular area in the mesentery overlying the UPJ in a manner so as to avoid injury to any major mesenteric vessel. With a combination of blunt and sharp dissection with the robotic monopolar hot scissors and the robotic bipolar forceps, the UPJ is dissected free from the surrounding soft tissue attachments through the mesenteric window, Figure 2a. Excision of the UPJ, reduction pyeloplasty (if indicated), lateral spatulation of the ureter and a stented anastomosis, Figure 2b, are performed with robotic assistance. The reduction pyeloplasty is performed by using the robotic hot monopolar robotic scissors and the bipolar forceps in a manner so as to subtract the redundant pelvis and achieve a proximal residual tapered renal pelvis. The ureteral spatulation is performed by holding the obliquely cut end of the ureter with the robotic bipolar forceps and inserting the robotic hot monopolar scissors and incising it on its lateral aspect for a length of about 1.5 cm. The technique of robot-assisted laparoscopic antegrade stenting has been described by us later in this manuscript. After completion of the anastomosis (detailed later) the mesentery is closed with a continuous 3-0 vicryl suture.

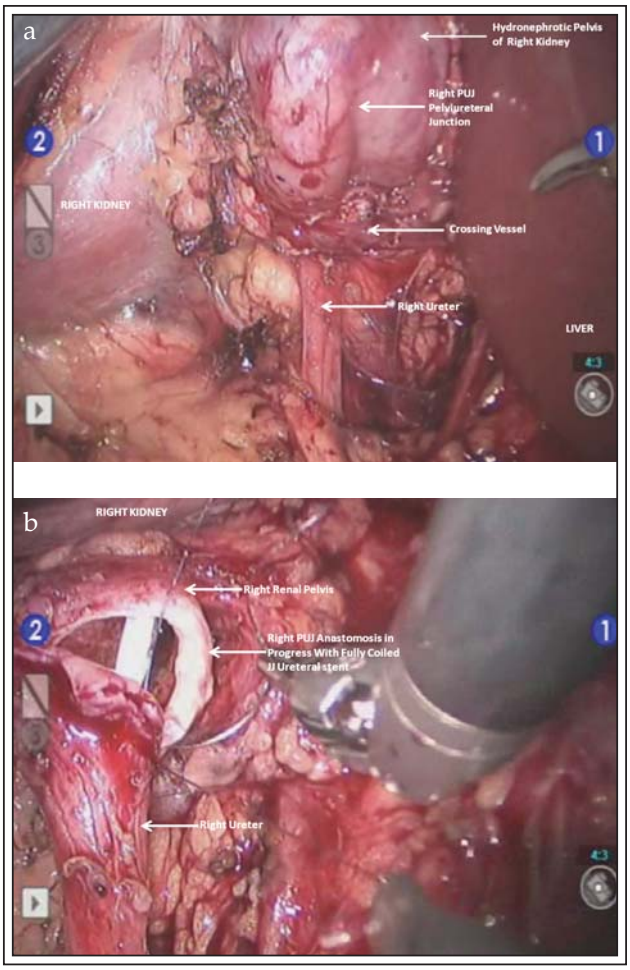

Figure 2. a) An endocamera view of the dissected right renal hydronephrotic pelvis, the right ureteropelvic junction the right ureter with the crossing vessel at the right ureteropelvic junction; (b) An endocamera view of the right anastomotic pyeloplasty in progress over a JJ stent.

Transperitoneal laparoscopic access to the UPJ is achieved by reflecting the colon and the mesentery medially exposing the ureter and pelvis. Under robotic control, by using a combination of blunt and sharp dissection with the right monopolar scissors and a left bipolar PK forceps the ipsilateral colon is reflected and retracted medially along the line of Toldt, exposing the kidney. In the robot-assisted technique of retroperitoneoscopic pyeloplasty, the kidney is approached posteriorly; the psoas muscle is identified with the ureter running anteriorly that is followed till the inferior pole of the kidney and the renal hilum. The renal hilum area is dissected identifying the renal vein, artery, and pelvis. By using the landmark provided by the psoas muscle and the gonadal vein on the right (may be clipped if needed) the UPJ is exposed down to the proximal ureter.

After placing stay sutures on the pelvis, the stenotic UPJ segment is transected, excised, and the divided ureteral end is spatulated on the lateral side for a length of 1 cm, excising any redundant pelvis. A JJ stent preloaded on a guide wire is inserted with its floppy tip facing proximally in an antegrade fashion through one of the robotic/costovertebral ports, manipulated by the robotic graspers and guided under vision distally in to the spatulated ureter, the guide wire is then disengaged carefully while grasping the stent with the robotic forceps while the guide wire is withdrawn out via the port by the assistant. The proximal coil of the JJ stent is then manipulated in to the tapered renal pelvis. Anterior crossing vessels if any are preserved by either dismembering the pelvis and doing a posterior translocation of the crossing vessel and performing the pyeloplasty anterior to it or alternatively by a vascular relocation procedure that involves superior translocation and fixation of the crossing vessel proximal to the UPJO (Hellstrom's procedure).

For dilated baggy renal pelvis the excess of the endopelvic tissue is excised and by using 5-0 Monocryl sutures and dismembered Anderson-Hynes pyeloplasty is performed. The initial throw of the same suture is used to secure the spatulated ureter to the dependent part of the renal pelvis, and subsequently two additional running sutures are placed for completing the anterior and posterior wall of the anastomosis. After completing on one side of the anastomosis, a ureteral stent is placed with a preloaded straight guide wire in an antegrade manner inserted through one of the assistant ports, manipulated distally in to the ureter and proximally in to the pelvis and the rest of the anastomosis is then completed sequentially. The renal pelvis is repositioned behind the renal vessels, and the Gerota's fascia is closed with 2-0 Vicryl suture. Alternatively the suture is prepared by tying two 5-0 monocryl sutures (dyed and undyed) to make a single suture with two needles and the rest of the anastomosis is completed similarly in two hemi-circles. The kidney is retroperitonealized by replacing the colon and suturing the peritoneal fold with continuous 3-0 vicryl sutures using the robotic needle driver. For patients with focal stenosis/without any crossing vessels, in whom a robot-assisted nondismembered Fengerplasty is intended, a longitudinal incision is usually made through the stenotic area of the UPJ, extending to about 1 cm on either side of the stenotic area, this is then closed transversely using 4-0 Vicryl interrupted sutures.

For UPJO associated with a high insertion of the ureter a Foley Y-V plasty is preferred where in a

'V' shaped flap is made on the pelvis with its base positioned on the medial aspect of the pelvis and its apex positioned at the UPJ. This is then extended laterally on to the proximal ureter across the UPJ stricture so that the apex of the flap lies alongside the ureterotomy. The anastomosis is performed between the ureterotomy and the anterior pelvic wall flap.

For UPJO associated with long proximal ureteric strictures, Davis intubated ureterotomy is performed by incising the stricture and allowing it to heal by re-epithelialisation over a JJ stent.

The robot is undocked and a drain (optional) is placed in the perinephric space under vision and is brought out through a separate stab incision. We feel that a perinephric drain in the presence of a JJ stent is not necessary in a majority. However we do advocate the placement of a drain in cases of repair of a secondary UPJO/salvage pyeloplasty due to higher risks of possible urinary leak and in the retrocolic approach where colonic or extensive renal mobilization may have been performed. The bowel is repositioned and secured with a 2-0 Vicryl suture. The ports are removed and closed at the fascia level using 0 Vicryl suture(s). The incisions are closed with 4-0 Monocryl suture and sealed with Dermabond (2-octyl cyanoacrylate-Ethicon, Inc., Somerville, NJ, USA) adhesive.

Follow up

The Foleys catheter and the drain are generally removed at 48 hours following surgery. Stent removal is generally done at 8 weeks. Subsequently follow up with a diuretic renogram is performed at 3rd month and annually thereafter provided the initial renogram is satisfactory. A successful result is defined by a combination of patent UPJ on the nuclear renogram and a subjective improvement in the patient analog pain scores.

Results

In recent appraisal of a series of 24 cases of transmesocolic RAP reported from a single centre, by Gupta and co-workers[16] these authors successfully reported on the safety and feasibility of the transmesocolic robot-assisted procedure with comparable operative times (mean ORT: 125.33 $\pm$ 23.48 and suturing time: 43.58 $\pm$ 15.15 minutes), a mean hospital stay of 2.5 days and satisfactory long term outcome (mean follow up ~12 months). These authors had placed a drain in all their cases without any major complication being reported. One of their patients had fever with prolonged drainage due to a misplaced stent that later required an additional procedure for its cystoscopic repositioning.

For UPJO associated with nephrolithiasis, concomitant robot-assisted pyelolithotomy is also feasible prior to the pyeloplasty, as previously described by others.[17,18] Concomitant management of renal pelvic stones during a RAP has been described by Atug et al[19] who had reported a 100% success rate without any delayed complications in eight patients with UPJO and nephrolithiasis. The robot-assisted laparoscopic technique as well as the purely laparoscopic technique of excision and successful repair of the retrocaval ureter is feasible that has been previously reported by others elsewhere.[20,21] Concomitant laparoscopic nephroplication and nephropexy along with laparoscopic repair of the UPJO has also been previously described in the literature.[22,23] Table 1 shows the salient features of published series of RAP published in the English literature till date.[11,19,24-43]

Perioperative outcomes

ORT

A review of published reports on RAP, Table 1 reveals that the mean ORT is about 207 (60-510) minutes, depending upon the level of expertise. In experienced hands the robot console time (CT) is ~ (50-76) minutes. The ORT varied depending on whether it was a primary or a secondary (redo) pyeloplasty and whether transperitoneal or retroperitoneal access was employed. Some workers have shown that the ORT may be longer in cases of secondary UPJ repair following failed pyeloplasty.[41] The surgeons learning curve may also impact the overall ORT.[43] More over the ORT may vary depending on whether the duration of cystoscopy, retrograde ureteropyelography and or stent placement was included or not. Most reported studies depicted in Table 1 have included these as a part of the overall operative duration. Additional procedures such as stone removal may prolong the ORT.[35] Never the less RAP[12] has decreased the difficulty of intracorporeal suturing and considerably shortened the prolonged ORTs and the steep learning curve that were associated with LP.[6,10,12,29,44,45] Schwenter et al, reported (92 cases of RAP) a mean anastomotic suturing time of 24.8 minutes.[29] Patel et al also reported a mean anastomotic suturing time of 20 minutes (mean overall ORT of 91 minutes) in the latter 10 of their 51 cases of RAP.[35] This also signifies the fact that the ORT of RAP, including the suturing time tends to significantly decrease with increasing experience.

Impact of crossing vessels

Crossing vessels are known to be associated with the occurrence of UPJO that may influence the treatment of

UPJO. A review of the published data of RAP, Table 1, reveals that crossing vessels were present with UPJO in almost half the cases, with a mean of 45% (0%-69%). In our opinion as far as possible anterior crossing vessels should be preserved. In case these interfere with the anastomosis despite mobilization of the ureter and renal pelvis, it is better to transpose the ureter.[24]

Estimated blood loss (EBL)

A comparison of the published series depicted in Table 1 shows that the mean estimated blood loss in RAP has been about 50 mL (0 mL-600 mL).[12,13,19,24,26-29,31-33,35-42] Studies have shown that the EBLs are comparable to pyeloplasty performed conventionally/RAP, without any statistically significant difference.[12,32]

Length of hospital stay (LOS)

The average LOS in a series of RAP, Table 1, is about 3.2 (1-11) days, however in most of these series it was ~2 days.[19,24,26-37,40-42] Studies have shown that while the LOS appears to be similar following conventional pyeloplasty/RAP, the trend of LOS appeared to be relatively shorter with RAP.[32,42]

Perioperative complications

A review of the published literature, Table 1, suggests that the average perioperative complication rate is about 6% (0%-16%). Majority of these reported complications were minor related to stent displacement, hematuria, ileus, prolonged drainage and urinary tract infections.[27,29,33,37,38,41,42] Others have also reported the occurrence of other complications like urinoma, pyelonephritis, compartment syndrome and nephrectomy too.[13,27,36,37] In one of the largest series by Muffariz et al[27] comprising 140 cases of UPJO managed by RAP, the authors reported a 7.1% major and 2.9% minor complication rate.

Functional outcomes

The mean follow up of the selected series of RAP, Table 1, is ~ 14.9 (1-51) months. Bernie et al,[42] reported no difference in the outcomes following LP performed with/without robotic assistance. Weise et al,[32] also reported a similar short term outcome of RAP versus LP. In a single centre 5 year experience with 92 cases of RAP, (including 12 cases of secondary UPJO) the authors reported a 100% patency rate (96.7 success rate) without any conversions, and acceptable cosmesis (mean follow up of 39.1 months).[29] Patel et al also reported a success rate of 100% in their 51 cases of RAP (mean follow up of 11.7 months).[35]

Discussion

To date Muffraiz et al, have reported one of the largest series of RAP (140 cases) demonstrating the overall safety and durability of RAP for both primary and secondary UPJO.[27] A recent review of the literature shows these have been mostly performed transperitoneally.[19,25-29,32-41] The advantages of the transperitoneal approach include; availability of a larger working space and a greater familiarity with the anatomical landmarks. The transmesocolic approach is anatomically and surgically well suited to RAP for the left sided UPJO. Some workers have also described and reported on the feasibility of robot-assisted retroperitoneoscopic pyeloplasty.[24,30,31] The advantages of the retroperitoneoscopic approach include; direct access to the UPJO , confinement of any urinary leak to the retroperitoneum, avoidance of peritoneal transgression, ileus and minimal chances of bowel injury. Problems of the retroperitoneal approach include limited working space, difficult intracorporeal suturing, difficulty in identifying lower polar anterior crossing vessels, overcrowding of the ports, instrument collision, and the need to position the robot more cephalad.[24] The retroperitoneal approach could be used in patients of UPJO with prior multiple transperitoneal surgeries. However until more data emerges we feel that retroperitoneoscopic approach should not be the initial preferred approach to laparoscopic repair of the UPJO.

RAP in secondary UPJO

Redo pyeloplasty is a technically challenging procedure.47[1] RAP[28,40] or LP[47] may be feasible for the repair of select patients of secondary UPJO. The challenges associated with secondary pyeloplasty are chiefly on account of adhesions and variable reactionary peripelvic fibrosis due to urinary leakage, bleeding or excessive use of thermal energy in the vicinity of the UPJ following its primary repair. According to these authors[28] the actual benefits perceived to be associated with RAP for secondary UPJO were; the relative ease of performing dissection, precise delineation of the scarred tissue, better preservation of the periureteral sheath encompassing the ureteric blood supply, with tailoring of ureteral and pelvic flaps, for suturing a leak proof anastomosis. It is prudent to be aware of potential adhesions around the UPJO especially on the right side in a secondary UPJO, due its anatomical proximity to the inferior venacava. While secondary UPJO repair appears to be more prone to failure, RAP appears to be a good modality even for these complicated cases in select situations, with the overall success rate being

even higher (91.6%) in at least some series[29] than that has been reported in the past with pure LP (80%).[47]

RAP for pediatric UPJO

RAP has also been successfully performed both via the retroperitoneal and the transperitoneal approach in the pediatric patients with UPJO, by several workers.[30,31,33,34,38] Though the pediatric laparoscopic technique of UPJO repair appears to be technically demanding procedure, the availability of robotic assistance and equipment has considerably decreased the ORT due to the relative ease of intracorporeal suturing. Due to intraoperative space constraints, we feel that the retroperitoneal approach to repair of the UPJO should be used only in the older children with prior history of transperitoneal surgery.

Advantages of robot assistance

The advantages of RAP over pure LP includes: motion scaling, tremor obliteration, three dimensional stereoscopic vision, and simplified precise suturing of the pelvis. Other workers[12] have also shown that RAP is associated with shorter anastomotic and ORT. Depending on the degree of expertise achieved and the economic viability of an institution affording a da Vinci robot, LP with or without robot assistance remains an effective therapeutic option for UPJO.[6,48] that may be expanded to include patients with concomitant renal congenital anomaly,[49] lower polar crossing vessel, failed prior endopyelotomy,[28,40,47] and renal calculi.[19,27]

Current advances

Recently Desai and colleagues reported on scar-less single port transperitoneal LP performed by using a triport inserted through a single umbilical incision and a 2 mm subcostal needlescopic port without any extraumbilical incision(s). Their reported ORT, EBL and LOS were 2.7 hrs, 50 cc and 2 days respectively.[50] Subsequently they also reported on two cases of bilateral simultaneous pyeloplasty in bilateral primary UPJO that were performed after a preplaced JJ ureteral stent, by using the same single access multichannel triport (R-port, Advanced Surgical Concepts, Dublin, Ireland) enabling surgery through a single obscured infraumbilical incision.[51] Another multichannel port also available for similar single port procedures includes the Uni-X port (Pnavel Systems, Morganville, NJ, USA). However though the single port transumbilical laparoscopy or [embryonic natural orifice transumbilical endoscopic surgery (E-NOTES)], appears to be encouraging, according to Canes and colleagues, these were plagued with the problems of triangulation, difficult retraction, instrument crowding, restricted vision and patient limitations.[52] RAP has also been successfully described transperitoneally without isthmusectomy, as a feasible procedure in the management of UPJO in patients with anomalous or horseshoe kidneys.[49] Concurrent bilateral RAP in a group of five children has also been described in the literature.[53]

Technical advances and improvements in the technique, instrumentation are likely to expand the entire spectrum of surgery including the way the future laparoscopic ablative and advanced reconstructive urological procedures are likely to be performed. In future flexible (elephant trunk technology based) roof top, magnetic or miniaturized robotic systems may occupy the modern operating room.

Conclusion

A review of the recent selected series from the published English literature (Pubmed) reveals that currently more than 740 RAP have been successfully performed worldwide over the past 8 years. This testifies to the overall safety and efficacy of RAP as a minimally invasive procedure. The short term results appear to be similar as compared to those achieved with conventional LP. The notable advantage of RAP over LP appears to be on account of the relative ease in acquiring skills needed for intracorporeal suturing, that is greatly simplified. Tremor free meticulous dissection, precise suturing and superior stereoscopic three dimensional vision also contributes to the overall superiority of RAP. A recent study from Asia also confirms that RAP is an effective technique for managing UPJO, with low morbidity, rapid recovery and resilient success rate.[54]

Due to the initial high current cost of the robot/equipment and consumables, RAP remains a costly procedure outweighing the cost of standard LP. The potential cost benefits of RAP and long term benefits remain to be ascertained, as this remains an area of ongoing concern. □

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