A Comparison Between Laparoscopic and Robot-Assisted Laparoscopic Pyeloplasty in Patients with Ureteropelvic Junction Obstruction

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ABSTRACT

Background   The aim of this study is to compare the results of laparoscopic pyeloplasty and robot-assisted laparoscopic pyeloplasty in patients with ureteropelvic junction obstruction.

Methods   Between March 2008 and May 2019, the patients who underwent retroperitoneal laparoscopic or robotic-assisted laparoscopic pyeloplasty in our institution were retrospectively reviewed.

Results   Thirteen patients underwent laparoscopically, and 12 patients underwent robotic surgery. The significant difference was found in median operative time between laparoscopic group (296 minutes) and robotic group (199 minutes) ($P = 0.001$). The median time for drain removal in laparoscopic group was longer than robotic group (3 vs. 2 days, respectively, $P = 0.029$).

Conclusion   Laparoscopic and robot-assisted laparoscopic pyeloplasty is safe and excellent success rates in patients with ureteropelvic junction obstruction. However, our experience study suggested that robotic surgery improves a total operative time, decreases drain removal time and less intraoperative blood loss than laparoscopic approach.

Key words   laparoscopic surgery; pyeloplasty; robotic surgery

In 1891, Kuster described the first successful pyeloplasty which has been considered the gold-standard treatment for ureteropelvic junction obstruction (UPJO), with success rate exceeding 90% (90–100%).[1–3] Later within these two to three decades, a procedure of minimally invasive surgery (MIS) has been developed and gradually famous and become an accepted treatment option with varieties procedures including endoscopic pyelotomy, laparoscopic pyeloplasty (LP) and robot-assisted laparoscopic pyeloplasty (RALP).

Although LP and RALP present success rates at a level comparable to those of open surgery, these two procedures has provided the advantages of lower morbidity, less postoperative pain, faster recovery time and shorter hospital stays.[4–7] Schuessler et al. were the first one to do laparoscopic pyeloplasty in 1993.[8] Since then, the procedure have published its popularity. However, anastomosis of ureteropelvic procedure is still considered as a hard and challenged for LP. The procedure demands advanced laparoscopic skill with a present of steep learning curve. These are limitations for a novice surgeon with low laparoscopic surgery skill.

With high technology development of robotic-assisted surgery, limitations occurred in LP surgery procedure have been gradually demolished. The procedure becomes less complex operative task, especially, reconstructive procedures for anastomosis suturing. These circumstances contribute towards the ongoing goodwill of RALP. However, robotic system exhibits limitations on lacking of tactile feedback sensation, wasting of docking time for setting up an assisting surgical robot instruments and highly supportive disbursement in several countries.[9]

Up to date, there's still no confirmation that RALP has significant impact on outcomes over LP. To explore this issue, this retrospective study aimed to compare outcomes between LP and RALP in patients with UPJO by our single center.

MATERIALS AND METHODS
Design and setting
The study protocol and approval to conduct this study was obtained from the local institutional research and ethics Board. The medical records of all patients who underwent LP or RALP due to UPJO between March 2008 and May 2019 were retrospectively reviewed. All patients were confirmed diagnosis of UPJO by renal ultrasonography (US), intravenous pyelogram (IVP)

(optional), computerized tomography (CT) scan and a diuretic renogram. The indications for surgery are renal pain, urinary tract infection (UTI), stone formation, decrease renal function (split renal function < 40%), obstructive pattern on diuretic renogram, progressive hydronephrosis on serial US examination and progressive loss of renal function on serial radionuclide renograms. The LP has been previously performed in 2008 through 2012. Since 2013 when the da Vinci® Si robotic system (Intuitive Surgical, Sunnyvale, CA) arrived in our hospital, all patients has been undergoing RALP.

The data collected from the chart review included patient demographics, preoperative evaluation, perioperative data (including total operative time, robotic docking time, and robotic console time), and postoperative results. Operative time was defined from the time of skin incision to skin closure, including docking time. Perioperative and postoperative complications were classified based on Clavien and Dindo classification.[10] The degree of hydronephrosis was grade of 0 to 3 according to Ellenbogen's grading system.[11]

The primary outcome of our study was the success rate of surgery. This was defined as relief of symptoms as well as improve obstruction on a diuretic renogram at 6 to 12 months after surgery. The secondary outcome included operative time, length of hospitalization (LOH), estimated blood loss (EBL) and complications.

Surgical procedure

The Anderson-Hynes dismembered technique was performed in all patients for both LP and RALP group. The LP was performed retroperitoneally, whereas the RALP was an intraperitoneal approach. All patients were positioned in the standard flank position. The LP procedures were performed by one surgeon who passed the Endoscopic Surgical Skill Qualification System in Urological Laparoscopy established by the Japanese Society of Endourology and Robotics. The RALP procedures were performed by two surgeons who passed the Endoscopic Surgical Skill Qualification System in Urological Laparoscopy and Proctor Qualification System for Urological Robotic Surgery established by the Japanese Society of Endourology and Robotics. And the two surgeons who performed RALP did not perform LP as surgeons or assistants.

Retroperitoneal laparoscopic pyeloplasty

Our technique for LP has been described in the previous study.[12] A camera port was made in the middle axillary line at the midpoint between the 12th rib and the iliac crest. A balloon dissector was used to create retroperitoneal space, a 12–mm trocar was placed. One working port was placed 7 cm dorsal to the camera port and two ports were placed in the anterior axillary line at the level of the iliac crest and in the subcostal region. Following exposure of the psoas muscle and the Gerota's fascia, the ureter was identified and mobilized to the ureteropelvic junction (UPJ). The stay suture was placed passed to the renal pelvis and pulled out through the abdominal wall. The ureter was spatulated laterally and the stenotic segment of the UPJ was resected. A 6F ureteral stent was inserted into the ureter by antegrade fashion. The anastomosis was performed with a running suture using a 4–0 polydioxanone suture. The anterior anastomosis was initially completed, followed by the posterior anastomosis with the same suture. The crossing vessels were preserved by anterior transposition of ureter and pyelo-reduction was performed if necessary. If renal calculi were present, the stones were removed before anastomosis by laparoscopic graspers or by using flexible nephroscope with a stone basket through the 12-mm port.

Robot-assisted laparoscopic pyeloplasty

The transperitoneal approach was our preferred in RALP. The position of the ports as shown in Fig. 1. A 12-mm camera port was made 6 cm lateral to the umbilicus by open Hasson technique. The 8-mm robotic arm ports were placed laterally at a distance of 8 cm from the camera port. The first assistant port was set at a distance of 6 cm from the midpoint between the caudal robot's arm port and the camera port. The da Vinci® robotic system was placed on the dorsal side of the patient.

The operation started with colon mobilization, allowing the colon to fall medially. Gerota's fascia was exposed. The ureter was identified and dissected up to UPJ. The rest of the surgical steps were almost the same as LP, except RALP did not need to stabilize the renal pelvis by stay sutures. Because of freedom of robotic arms, it was easy to perform anastomosis without any fixation.

Follow up

The ureteral stent was removed at 4 weeks after surgery. Follow up was scheduled for evaluation of clinical, urine examination and the renal US. A diuretic renogram was also performed at 6 to 12 months postoperatively.

Statistical analysis

We used the Student T-test for comparison between two groups that showed equal variance. On the other hand, the Mann-Whitney test was used between two groups showing non-normal distribution or non-uniform
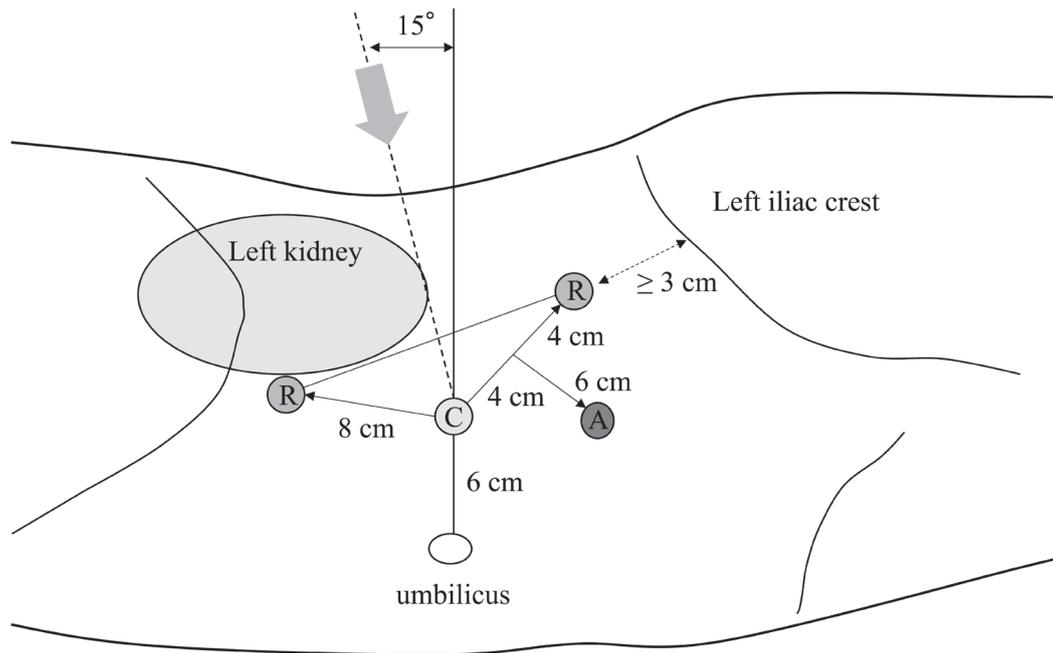
Fig. 1. Trocar placement for left robotic-assisted pyeloplasty. A, Assistant port (12 mm); C, Camera port (12 mm); R, Robotic arm port (8 mm).

variance. In addition, in comparison of the ratio between the two groups, a chi-square test was used. For each test result, a corresponding two-sided *P*-value of < 0.05 was considered statistically significant. All analyses were performed using SPSS software (IBM, Statistical Package for the Social Sciences ver 23, Chicago, IL).

RESULTS

A total of 25 patients were included in this study. Thirteen and 12 patients underwent LP and RALP, respectively. Patient demographics and characteristics data are shown in Table 1. There were significantly higher BMI in LP group than RALP group (*P* = 0.012). However, the gender, age, side, clinical presentation, and history of previous surgery were similar in both groups. The crossing vessels were encountered in 5 (39%) patients in LP group and 4 (33%) patients in RALP group and they could be preserved in all cases. Two (15%) patients in LP group had concomitant stones compared with 2 (17%) patients in RALP group.

The median operative time for RALP, including docking time, was significantly shorter than LP (296 minutes vs. 199 minutes in LP and RALP, respectively) (*P* = 0.001), while the median robotic docking time was 6 minutes (range 2 to 17) (Table 2). There was no significant difference in the median EBL between LP and RALP (5 mL vs. 0 mL, respectively) (*P* = 0.168). However, 2 cases in LP group had significant blood

loss (305 and 600 mL), but all of them did not require a blood transfusion. Regarding complications, no intra-operative complications were observed in both groups. While in postoperative period, one patient in the RALP group was Clavien-Dindo level IIIa. This patient had ureteral stent obstruction by a blood clot, which required to change stent by cystoscopy under local anesthesia. The median time for drain removal in LP group was 3 days (range 2 to 4), which is significantly more than 2 days (range 1 to 4) in RALP group (*P* = 0.029). The median length of hospital stay after surgery was similar in both groups were equivalent at 8 days (*P* = 0.677). The success rate, defined as resolution of symptoms and improvement of obstruction on a diuretic renogram, were similar at 100% for both groups. No open conversions were required for all patients. The median follow-up was 24 months.

DISCUSSION

At the present, LP and RALP surgery have become alternative procedures with a minimally invasive surgery for the treatment of UPJO. The highly popular procedures displayed treatment effectiveness at a high level comparative to that of open pyeloplasty which once was the gold-standard surgery in the past.[13] Furthermore, these procedures provided the advantages of lower morbidity, less postoperative pain, and shorter hospital stays. Nevertheless, it was found that LP demanded high

Table 1. Baseline demographics and disease characteristics (*n* = 25)

	LP, *n* = 13	RALP, *n* = 12	*P*-value
Age, yrs (range)†	23 (12−62)	29 (11−70)	0.557
Sex: male/female	7 / 6	8 / 4	0.688
BMI, kg/m^2 (range)†	22.2 (16.6−25.0)	18.4 (12.9−21.9)	0.012
Side: right/left	4 / 9	4 / 8	0.891
Presentations			0.961
Pain	9	9	
UTI	2	1	
Hematuria	1	1	
Incidental finding	1	1	
Crossing vessels, *n* (%)	5 (38.5%)	4 (33.3%)	0.79
Concomitant stones, *n* (%)	2 (15.4%)	2 (16.7%)	0.93
Previous surgery, *n* (%)	2 (15.4%)	0 (0%)	0.157

†Age and BMI were expressed as "Median". BMI, body mass index; LP, laparoscopic pyeloplasty; RALP, Robot-assisted pyeloplasty; UTI, urinary tract infection; yrs, years.

Table 2. Perioperative and postoperative outcome

	LP, *n* = 13	RALP, *n* = 12	*P*-value
Total operative time, min (range)†	296 (185−498)	199 (173−296)	0.001
Robot docking time, min (range)†		6 (2−17)	
EBL, mL (range)†	5 (0−600)	0 (0−50)	0.168
Complications			
Intraoperative	0	0	
Postoperative: Clavien-Dindo Grade IIIa, *n*	0	1	
Drain duration, days (range)†	3 (2−4)	2 (1−4)	0.029
Hospital stay, days (range)†	8 (5−15)	8 (6−13)	0.677
Conversion to open surgery, *n* (%)	0	0	
Success rate, *n* (%)	13 (100%)	12 (100%)	

†Total operative time, robot docking time, EBL, drain duration, and hospital stay were expressed as "Median". EBL, estimate blood loss; LP, laparoscopic pyeloplasty; RALP, Robot-assisted pyeloplasty.

intracorporeal suturing skill and longer operative time comparative to open surgery.[14]

After the robotic system has been introduced to operative treatment, various limitations on laparoscopic surgery could be demolished including decreased learning curve, reduced fatigue of a surgeon during surgery operation and increased effectiveness of operative treatment. With 3 dimensional visualization (3D) including freedom movement of robotic wrist, stable view, tremor filtering, and motion scaling, RALP procedure has gained higher popularity among surgeons.[15, 16]

Braga has conducted a meta-analysis to compare LP vs. RALP treatments from 8 research studies which showed success rate exceeding 90%, and 5 of which exhibited success rate at 100% for both LP and RALP. It was found that success rates of RALP were higher than those of LP (100% vs. 97% and 99% vs. 97%) in 2 studies. In contrast, there was only one study reported that success rate of LP was greater than that of RALP (100% vs. 97%). However, the difference showed no statistical significance.[17] Moreover, our study found that success rates of both LP and RALP were equivalent at 100% when evaluation was performed from relief of symptoms and improve obstruction on a diuretic renogram.

Furthermore, there was no open conversion discovered in both groups. Additionally, our study has disclosed that median operative time of LP was 296 (185−498) minutes, whilst that of RALP was 199 (173−296) minutes. The results suggested that RALP employed shorter total operative time comparative to that of LP with statistical difference. Light et al. has performed a meta-analysis study to compare the operative time of LP and RALP in both children and adults from 14 research studies.[18] The results indicated that there were 4 studies showing comparatively identical operative time in both LP and RALP. Whilst, there were 8 studies exhibiting shorter operative time in RALP compared to that of LP with statistical significance. In contrast, there were 3 studies showing that LP statistically significantly display shorter operative time comparative to RALP. According to the results from meta-analysis studies performed by Light et al., it can be concluded that RALP employed operative time shorter than LP for 27 minutes. Interestingly, it was believed that assisted robotic surgery involved shorter anastomosis suturing comparative to that of laparoscopic surgery.[18]

However, Link et al. has reported that LP displayed operative time shorter than that of RALP with statistical significance.[19] Furthermore, RALP surgery could expedite anastomosis suturing procedure, though, some operative steps, such as colon reflection, consumed more time comparative to laparoscopic surgery since the robotic arms have been designed to operate with more effectiveness for precise than gross movements. Additionally, the robotic system consumed more time for robot docking and undocking.[20] Moreover, especial novice surgery center with low experience in robot-assisted surgery would consume more time for setting up procedure. Therefore, the operative time not only depended upon surgeons, but also experience and masterfulness of the entire robotic team.[18, 21]

Lucas et al. has reported a study comparing the surgery results by LP and RALP, performed in 274 and 465 patients, respectively.[22] No statistically significant difference has been found in intraoperative complications, postoperative complications and anastomotic leak. In our study, intraoperative complications were not observed in both groups. However, it has been found that there was intraoperative significant blood loss among 2 patients operated by LP (305 and 600 mL, respectively), but blood transfusion was not required. Furthermore, one case in this group was previous performed balloon endopyelotomy with no success, therefore, it was difficult during LP surgery as a result of adhesion leading to renal parenchymal tear. Moreover, bleeding from inadequate renorrhaphy was indicated in another case

in this group. Fortunately, laparoscopic suturing was achievably conducted to stop bleeding in both cases. For RALP group, there was 1 case discovered with postoperative complication from ureteral stent obstruction by blood clot. The patient was performed cystoscopy with stent changing under local anesthesia. Subsequently, there was no further postoperative complication found later.

In our research, we found that drain removal could be performed earlier in RALP group comparative to LP group with statistical significance. Median time for drain removal in RALP and LP groups were 3 (2−4) days and 2 (1−4) days, respectively. Since the RALP surgery encouraged a surgeon to certainly qualify anastomosis suturing procedure comparative to that of LP, the drain removal in RALP group could be conducted earlier. The results from meta-analysis performed by Light et al. has found that LOH in RALP was shorter than that in LP for 1.2 days.[18] In contrast, our research discovered that it was comparatively the same between both groups, 8 (5−15) days for LP versus 8 (6−13) days for RALP. The causes of longer LOH in our research was that the patients were regularly allowed to stay in hospital until drain and Foley catheter were off and patients get normal routine activity. Some patients were worried of the distance between the hospital and their residences and demanded to stay longer at the hospital to assure their recovery. In comparison with a study of Patel et al., which has reported 1.1 days for LOH, whilst the recovery time until the patients could continue all routine independent activities of daily living was 7.7 days, this recovery time and our LOH were comparatively similar to each other.[23]

There are several limitations to this study. First, the pooled sample size was not powered to compare the results of LP and RALP in patients with UPJO. Moreover the design of this study was a retrospective review. Consequently, a retrospective or prospective, multi-center, cohort study taking into consideration the limitations of this study is needed to confirm the results. Secondly, the LP and RALP procedures was performed by more than one surgeon, each with different levels of experience. Therefore, this may have an impact on the perioperative and postoperative outcomes of LP and RALP.

In era of minimally invasive surgery, LP and RALP treatments of UPJO have played critical roles and emerged widespread with equivalently qualified success rates comparatively the same to that of the standard open technique. The robotic surgical systems have been continuously developed to overcome the limitations of laparoscopic approach. In our study, we have clearly

indicated that RALP displayed higher advantages than LP in the features of shorter operative time, less blood loss and earlier drain removal. These merits assure us of using RALP as excellent, effective and harmless alternative treatment.

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