Comparison of surgical and functional outcomes of open, laparoscopic and robotic pyeloplasty for the treatment of ureteropelvic junction obstruction

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ABSTRACT

Objective: To compare the surgical and functional outcomes of open, laparoscopic and robotic dismembered pyeloplasty for the treatment of patients with ureteropelvic junction obstruction (UPJO).

Material and methods: Between 2007 and 2012, a total of 56 patients underwent conventional open (Group 1; n=25), laparoscopic (Group 2; n=16), and robotic (Group 3; n=15) dismembered pyeloplasty operations. Preoperative evaluation was performed using urinalysis, urine culture, blood biochemistry, urinary ultrasound, intravenous pyelogram (IVP) (optional) and Mercaptoacetyl triglycine (MAG-3) renal scan. The mean operation time, estimated blood loss, drain removal time, narcotic analgesic requirements, length of hospital stay and functional outcomes were compared among groups. Statistical analyses were performed using Statistical Package for the Social Sciences (SPSS) v. 20 (IBM, Armonk, NY, USA) software, and statistically significant differences were determined using a p value <0.05.

Results: The mean age of the patients was 30 years in Group 1, 34.3 years in Group 2 and 32.9 years in Group 3. The mean operation time was 127, 130 and 114 min (p=0.32), and the estimated blood loss was 105, 31 and 28 mL, respectively (p=0.001). The drain was removed after 4.36 (±1.3), 2.33 (±0.6) and 1.8 (±0.6) days after surgery (p<0.001), and the mean hospital stay was 4.14 (±1.8), 2.8 (±0.75) and 2 (±1) days, respectively (p<0.001). Narcotic analgesic requirement was significantly higher in Group 1 compared with Groups 2 and 3 (p=0.02). The radiographic and symptomatic success rates were 96% in Group 1, 93.75% in Group 2 and 93.3% in Group 3.

Conclusion: Laparoscopic and robotic pyeloplasty are feasible, effective, reliable and minimally invasive treatment approaches for the treatment of UPJO as compared with open dismembered pyeloplasty.

Key words: Laparoscopy; pyeloplasty; robot.

Introduction

Historically in ureteropelvic junction (UPJ) obstruction standard surgical treatment was open pyeloplasty. Surgical repair of the ureteropelvic junction was firstly performed by Trendelenburg^[1] in 1886. After Trendelenburg, many surgeons defined many surgical techniques. Nowadays, dismembered pyeloplasty technique described by Anderson, and Hynes^[2] is the most frequently used open surgical technique. Surgical success rate of this method has been reported to be over 95 percent. However, despite higher success rates of open surgery, its incisional morbidity has led to the development of minimally invasive techniques. Especially, during the last three decades, in line with technological advances, many minimally invasive treatment modalities of UPJ obstruction have been reported. Among them laparoscopic pyeloplasty (LP) was firstly described in the year 1993,

and in many studies, success rates similar to those obtained by traditional open dismembered pyeloplasty have been reported.^[3,4] Besides, thanks to shorter hospitalization periods, better cosmetic results, and advances in laparoscopic technology, it has been applied as a standard treatment modality for UPJ obstruction.^[5]

However its longer learning curve, and requirement of highly skilled intracorporeal suture technique are its most important disadvantages. To eliminate these disadvantages related to standard laparoscopy, in 1999 robotic pyeloplasty (RP) was described, and it has been accepted as effective, and reliable minimal invasive method in the treatment of UPJ obstruction.^[6] In this study we aimed to compare surgical, and functional outcomes of open surgery (Anderson-Hynes dismembered pyeloplasty), laparoscopic, and robotic dismembered pyeloplasty operations.

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Material and methods

A total of 56 patients who had undergone pyeloplasty between January 2007, and July 2012 with the diagnosis of UPJ obstruction were included in the study. The patients were divided in three groups based on surgical techniques applied as follows: open pyeloplasty (Group 1; n=25), LP (Group 2; n=16), and RP (Group 3; n=15). Data of the patients were prospectively recorded, and analyzed retrospectively. Besides, informed consent forms were obtained from all patients, and Anderson-Hynes dismembered pyeloplasty was performed. Preoperative evaluation, complete urinalysis, urine culture, blood biochemistry, urinary system US, intravenous pyelogram (IVP) (optional), and diuretic renal scans (MAG-3) were performed. On diuretic renal scan, a T1/2 value of >20 minutes was considered to be significant in favour of obstruction. Indication of pyeloplasty was made based on the presence of obstructive signs on diuretic renal scan, clinical state of the patient, and radiological findings. Surgical success was defined as subjective improvement in clinical symptoms of the patient, and objective improvement in obstructive findings on diuretic renal scan. Intraoperative, and early postoperative complications were evaluated based on modified Clavien classification system.^[7]

Statistical Analysis

Intergroup comparisons were performed as for operative, and postoperative data, mean operative times, estimated blood loss, drain stay time, need for analgesia, hospital stay, and postoperative dynamic scanning findings using Statistical Package for the Social Sciences (SPSS) 20 (IBM, Armonk, NY, USA) statistical program. For statistical comparison of parametric, and nonparametric variables among three groups ANOVA, and Kruskal-Wallis tests were used respectively. Comparison between LP, and RP was realized using sample *t*-test, and Mann-Whitney U tests. Pre-, and posttreatment variables in groups were estimated using paired samples *t*-test. $P < 0.05$ was accepted as the level of statistical significance.

Surgical Technique

Open pyeloplasty: All of these operations were performed by experienced physicians in the surgical treatment of UPJ obstruction. Flank (extraperitoneal lumbar approach; n=16) or dorsal lumbotomy (n=9) incisions were used to enter retroperitoneum. Perioperatively, a 4.7 F 26-cm double J-stent was delivered into the bladder through antegrade route. Ureteropelvic anastomosis was closed with continuous 4-0 polyglactine sutures with a RB-1 17 mm 1/2 Circle needle Jackson-Pratt drains were used for all patients.

Robotic, and laparoscopic pyeloplasty: Robotic, and laparoscopic pyeloplasty operations were performed by surgeons who

had an experience of more than 40 operations. All patients were laid in 60 degree-flank position pneumoperitoneum was created using a Veress needle. During the entire procedure, extreme care was taken to keep intraabdominal pressure at 12-15 mm Hg. For RP, a 12 -mm camera port was inserted 2 cm lateral to the umbilicus, and an 8 -mm robotic port was placed 4 cm medial, and cranial to the spina iliaca anterior superior. Another 8-mm-robotic port was inserted through the intersection point between the midclavicular line and the costal arch. Thus, all three robotic ports were placed at a 45 degree angle with the patient's head. A 12-mm assistant port was placed between the camera port, and the robotic port. The ports used for LP in 16 patients were also inserted through the same access sites. Transperitoneal approach was preferred in standard LP, and RP. In both methods, initially, colon was medialized. Gonadal vein was observed in the retroperitoneal cavity, and protected from surgical trauma. Through dissections along the course of the ureter, renal pelvis was approached. Dismembered pyeloplasty was performed in all patients (Figure 1A, B). During the operation a 4.7 F- ureteral stent was sent antegradely into the bladder. Anterior transposition was applied in the presence of intersecting veins. Anastomosis between the renal pelvis, and ureter was achieved using 4-0 RB-1 Vicryl sutures (Figures, 2A, B, 3A, and B). Before termination of the operation a Jackson-Pratt drain was placed *in situ*.

Figure 1. A) Transsection of renal pelvis and B) spatulation of the proximal ureter

Figure 2. A) Posterior and B) Anterior ureteropelvic junction anastomosis in laparoscopic pyeloplasty

Postoperative follow-up: Ureteral DJ stents were removed at postoperative 4 weeks. At postoperative 1. months, urine cultures were obtained, and urinalysis and urinary system ultrasound were performed. At postoperative 6., and 12. months MAG-3 renal scans were performed.

Results

Demographic data of the patients were presented in Table 1. Mean ages of the patients were as follows: Group 1, 30, Group 2, 34.3, and Group 3, 32.9 years, respectively. Both right (Group 1, n=11, Group 2, n=9, and Group 3, n=6), and left-sided (Group 1, n=14, Group 2, n=7, and Group 3, n=9) UPJ obstructions (UPJO) were operated on. Mean body mass indexes (BMIs) were 26.7 kg/m², 26.2 kg/m², and 26.4 kg/m² in Groups 1, 2, and 3, respectively (p=0.48). Mean ASA (The American Society of Anesthesiologists) scores were determined as 2.12, 2, and 3, in Groups 1, 2, and 3, respectively (p=0.17). Any statistically significant difference was not detected between groups as for BMI, and ASA scores. Vessels intersecting ureters from their anterior aspect were also observed in a total of 14 patients [Group 1, n=3 (12%), Group 2, n=5 (31.25%), and Group 3, n=6 (40%)]. All

of these patients underwent anterior transposition. Operative, and early postoperative data of the groups are given in Table 2. Mean operative times were 127, 130, and 114 minutes in Groups 1, 2, and 3, respectively. Mean operative times were not statistically significantly different between groups (p=0.32). In Group 3, mean operative time was calculated based on the console time. Estimated blood losses were 105, 31, and 28 mL in Groups 1, 2, and 3 respectively. In open pyeloplasty patients higher amounts of blood loss was determined relative to LP, and RP patients. (p<0.001). Mean drain stay times were 4.36±1.3, 2.33±0.6, and 1.8±0.6 days in Groups 1, 2, and 3, respectively. Statistically analysis revealed longer drain stay times in Group 1 (p<0.001). The difference between Groups 2, and 3 as for drain stay times was not statistically significant (p=0.47). Mean hospital stay was 4.14±1.8, 2.8±0.75, and 2±1 days in Groups 1, 2, and 3, respectively. Hospital stay in Group 1 was significantly longer than that of the Groups 2 (p=0.013), and 3 (p<0.001). A significant difference was not observed between Groups 2, and 3 as for hospital stay (p=0.5). Any intraoperative complication was not seen in three groups. Postoperative complications were also seen in Groups 1 (n=5), and 2 (n=1), and 3 (n=1).

Figure 3. A) Spatulation of the ureter in robotic pyeloplasty and B) Anastomosis of the ureteropelvic junction

Table 1. Demographic data of the patients			
	Open pyeloplasty	Laparoscopic pyeloplasty	Robotic pyeloplasty
Number of patients	25	16	15
Gender (Male/Female)	16/9	9/7	6/9
Side (Right/Left)	11/14	9/7	6/9
Mean age	30 (±15.4)	34.3 (±10.5)	32.9 (±14)
UPJ operation history	1	1	0
Concomitant stone (%)	5 (23%)	4 (27%)	1 (7%)
disease			
UPJ: ureteropelvic junction			

Table 2. Operative, and early postoperative data of the patients

	Open pyeloplasty	Laparoscopic pyeloplasty	Robotic pyeloplasty	p
Mean operative time (mins)	127 (±18)	130 (±45)	114 (±26)	0.32
Crossing vessels	3 (12)	5 (31.25)	6 (40)	0.17
Estimated blood loss (ml)	105 (±34.7)	31 (±18.6)	28 (±65.7)	0.001
Drain stay time (day)	4.36 (±1.3)	2.33 (±0.6)	1.8 (±0.6)	0.001
Hospital stay (day)	4.14 (±1.8)	2.8 (±0.75)	2 (±1)	0.001
Intraoperative complication	0	0	0	-
Postoperative complication	5	1	1	0.25
Reduction of renal pelvis	14 (63.6%)	13 (86.7%)	9 (60%)	0.22
Need for narcotic analgesic (mean mg)	9 (18.4)	1 (3.3)	1 (3.3)	0.02
Stent stay time (gün)	35 (±8.9)	42 (±13)	31 (±6)	0.01
Surgical success (%)	24 (96)	15 (93.75)	14 (93.3%)	0.90
Follow-up period (mos)	40 (6-69)	12 (6-18)	36 (12-48)	0.001

Table 3. Pre-, and postoperative $T_{1/2}$ values, and split renal functions as detected on diuretic renal scans in patients operated with open, laparoscopic or robotic pyeloplasty

	Open pyeloplasty	Laparoscopic pyeloplasty	Robotic pyeloplasty	P
Split renal functions (%)				
Pre- op	41.40	40.64	39.61	0.8
Post- op	46.09	37.67	39.64	0.08
P	0.01	0.21	0.99	
$T_{1/2}$ (mins)				
Pre-op	79	106.77	99	0.56
Post- op	10.86	12.33	13.29	0.08
P	0.001	0.001	0.001	

In the open pyeloplasty group anastomotic leak developed in 3 patients. Drain stay times in these patients were equal or more than 6 days. In 2 patients wound site infection developed which healed with appropriate medical therapy. In the robotic group, one patient received erythrocyte transfusion. In one patient in the laparoscopic group symptomatic urinary tract infection developed during the early postoperative period. All complications were categorized in Clavien stages 1, and 2. A significant difference was not observed among groups as for development of postoperative complication(s) ($p=0.25$). Patients who underwent open pyeloplasty required a mean dose of 18.4 mg (9/25; 36%) narcotic analgesic. When compared with the other two groups, need for narcotic analgesic was statistically significantly greater in Group 1 ($p=0.02$). A statistically significant difference was not observed between Groups 2, and 3 ($p=0.83$). In Groups 2, and 3, all operations were completed without any need of switching to the open surgery. Ureteral stents were removed on approximately 35., 42., and 31. postoperative days in Groups 1, 2, and 3, respectively. Mean follow-up periods were 40, 12, and 34 months in Groups 1, 2, and 3, respectively. Pre-, and postoperative split renal function test results revealed by diuretic renal scans, and $T_{1/2}$ values are given in Table 3. Pre-, and postoperative split renal functions, and $T_{1/2}$ values of the patients who underwent open pyeloplasty were 41.4%, and 79 mins vs. 46.09%, and 10.86 mins ($p=0.01$), respectively. In the laparoscopic group, mean pre-, and postoperative renal functions, and $T_{1/2}$ values were 40.64%, and 106.77 mins vs. 37.67% ($p=0.21$) and 12.33 mins, respectively ($p=0.001$). While in the RP group, mean pre-, and postoperative split renal functions, and $T_{1/2}$ values were 39.61%, and 99 mins vs. 39.64% ($p=0.99$), and 13.29 mins, respectively ($p=0.001$). In one patient in each group, symptomatic, and radiographic recurrent UPJO was detected. In these patients persistent obstructive drainage pattern was observed on diuretic renograms. Radiographical,

and symptomatic success rates were 96, 93.75, and 93.3% in Groups 1, 2, and 3, respectively.

Discussion

Despite higher success rates of open pyeloplasty, its disadvantages of incisional morbidity, postoperative requirement for analgesics, and longer healing period have led to the development of minimally invasive techniques. Minimally invasive approaches which are shown to be as alternatives to open procedures are antegrade, and retrograde endopyelotomies, Acucise® incisional endopyelotomy, percutaneous endopyeloplasty, LP, and RP.^[8] With these approaches, decrease in surgical morbidity of open pyeloplasty is aimed. Surgical success rates for antegrade, and retrograde endopyelotomies in published series have been reported as 65-93 percent.^[9,10] Compared with open pyeloplasty, higher recurrence rates seen during long-term follow-up periods have restricted application area of this method. Besides, in the presence of intersecting vessels, and in cases with large extrarenal pelvis, and poor renal functions, success rates of endourological methods decrease.^[11]

Nowadays, LP is being applied by very experienced surgeons with resultant higher success rates. In many studies, efficacy of laparoscopic approach has been compared with traditional open pyeloplasty, and similar success rates have been reported.^[12-15] Procedural success rate varies between 88-100%, based on subjective, and objective success criteria.^[16] Although when compared with open surgery, lesser incisional morbidity, postoperative pain, and shorter hospitalization period, requirement for highly experienced suturing technique, and longer operative times are seen as disadvantages of this method.^[17] Following first description of RP by Sung et al.^[18] many series have demonstrated its effectiveness, reliability, and safety. Da Vinci robotic surgical systems have been developed to eliminate disadvantages of standard laparoscopy, and the most predominant advantage over standard laparoscopy is ease in reconstruction, and intracorporeal suturing. Gettman et al.^[19] compared patients who had undergone LP or RP, and reported shorter operative, and anastomosis times for robotic surgery.

In our study we aimed to compare operative, and postoperative outcomes of open dismembered pyeloplasty with laparoscopic, and robotic pyeloplasties. Mean operative times were 127, 130, and 114 mins in open, LP, and RP. In our series, a statistically significant difference was not observed among all three groups. In our study, for robotic pyeloplasty operations, we have taken console times into consideration. However, it should be reminded that preparation time for robotic surgery might be prolonged in clinics with inadequate experience which might considerably increase operative times. In cur-

rent literature, a longer mean operative time was observed in patients who underwent LP. In a study conducted by Bansal et al.^[20] in 2011, the investigators determined mean operative times in patients who had undergone LP, and open pyeloplasty as 244, and 122 minutes, respectively ($p<0.01$). In this study where Bansal et al. compared LP with open method, and emphasized longer operative time of LP as the only disadvantage of this approach. Braga et al.^[21] published a retrospectively designed meta-analysis of operative data of RP, and LP. In this meta-analysis, the investigators underlined that operative times of RP, and LP were comparable in 3 studies, while in another 4 studies, operative time of RP was significantly shorter than that of LP. In conclusion, Braga et al.^[21] indicated that mean operative time of RP was 10 minutes shorter than that of the conventional laparoscopic pyeloplasty. However, Link et al.^[22] reported that operative time of LP was shorter than that of RP, and indicated that a robotic system did not offer any advantage to an experienced laparoscopist. In conclusion, since the most important influential factor on operative times is intracorporeal suturing skill, very diverse operative times have been reported in various publications based on the experience of the surgeon.

In our series, estimated blood loss was found to be significantly higher for open pyeloplasty, when compared with laparoscopic, and robotic pyeloplasties. In open pyeloplasty estimated blood loss was 105 mL, while in LP, and RP it was 31, and 28 mL, respectively ($p=0.001$). We think that, refraining from dissection of anterolateral abdominal wall muscles in LP, easier application of UPJ dissection with the aid of the imaging systems which yield images with higher resolution result in relatively lesser amount of blood loss. In the literature series, estimated blood losses appear to be less than 50 milliliter.^[23,24] When compared with open pyeloplasty, drain dwelling times, and length of hospital stays were significantly shorter in LP, and RP. Postoperative need for narcotic analgesics (median, 18.8 mg) was required for 8 patients in the open pyeloplasty group, while only one patient in the LP, and RP groups, required narcotic analgesics (median, 18.8 mg) during the postoperative period. Drain stay times ($p=0.09$), and need for narcotic analgesics ($p=0.83$) were similar in LP, and RP groups. However, mean hospital stay was shorter than that of the RP ($p=0.047$). In a study conducted by Bansal et al.^[20] lesser amount of postoperative analgesic requirement was reported in LP patients relative to open pyeloplasty (mean, 107.14 mg vs 682.35 mg, $p<0.01$). Besides in the same study, mean hospital stay was reported as 8.29 days in open pyeloplasty, and 3.14 days in the LP group ($p<0.01$). Bird et al.^[25] compared hospital stays in 74 LP, and 98 RP patients without any statistically significant difference between both groups ($p=0.95$).

In three patients who had undergone open pyeloplasties, an anastomotic leak which led to prolongation of the drain stay time (≥ 6 days). In the LP, and RP groups any anastomotic leak was not detected, and complication rates in all groups were similar to those cited in the literature. In a meta-analysis published by Braga et al.^[21] complication rates were similar in four studies. However in 3 studies they were slightly higher among patients operated with LP. In this meta-analysis, any difference between RP, and LP as for postoperative anastomotic leak was not reported. Lucas et al.^[26] reported the results of a multicentered collaborative study on laparoscopic, and robotic pyeloplasty. According to this meta-analysis of 485 RP, and 274 LP patients, any significant difference was not reported between intraoperative (1.9 vs. 2.2%; $p=0.67$), and postoperative (5.4 vs. 8%; $p=0.25$) complications, anastomotic leak (1.9 vs. 3.3%; $p=0.303$), drain stay time of ≥ 7 days (11.2 vs. 9.3%; $p=0.55$), and problems related to the stent (1.7 vs. 3.7%; $p=0.096$). Although, in our study, data of the robotic, and laparoscopic pyeloplasty patients were more favourable as for estimated blood loss, mean drain, and hospital stays, postoperative complications, and requirement for narcotic analgesics when compared with the open surgery group, scarce number of patients, and nonhomogenous distribution of groups because of retrospective evaluation, complicate conduction of statistical analyses within a higher confidence interval.

Literature reviews have revealed that LP, and RP have similar surgical success rates when compared with the open surgery. Surgical success rates have been reported as 94-100, and 93-100% in RP, and LP series respectively.^[28-33] In our series, at the end of at least 6 months of the follow-up period, surgical success rates based on subjective, and objective success rates in patients who had undergone open, LP, and RP were determined as 96, 93, 75, and 93.3%, respectively ($p=0.90$). Symptomatic, and radiographically recurrent UPJ obstruction was detected in only one patient in three groups. Improvements in pre-, and postoperative $T_{1/2}$ levels in all three groups were statistically significant. However improvement in postoperative split renal functions was statistically significant in Group 1, while preoperative values in Groups 2, and 3 were similar. Any statistically significant difference was not observed among three groups as for recurrence rates, and their surgical success rates were found to be in compliance with the literature findings.

Study limitations, major limitations of the study are scarce number of cases in relevant series, and retrospective design of the study.

In conclusion, in the treatment of UPJ obstruction, LP, and RP have success rates comparable to open dismembered pyeloplasty with lower incidence of blood loss, and shorter hospital stays. In addition, postoperative complication rates, and requirement for analgesics

sia are lower in patients who had undergone LP or RP. In the light of these data, in the management of UPJ obstruction LP, and RP are effective, and reliable minimally invasive treatment modalities.

Ethics Committee Approval: Due to the retrospective study design, ethics committee approval was not necessary.

Informed Consent: Written informed consent was obtained from patients who participated in this study.

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