DOI: 10.4081/aiua.2024.12431

ORIGINAL PAPER

Robotic-assisted laparoscopic pyeloplasty for the treatment of ureteropelvic junction obstruction – How should success be determined?

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Summary ***Background: Ureteropelvic junction obstruction (UPJO) is characterised by stenosis of the ureteral lumen at the level of the renal pelvis and proximal ureter. At Haukeland University Hospital, robotic-assisted laparoscopic pyeloplasty (RLP) for UPJO has been performed since 2014. The aim of this study was to evaluate the results of the treatment and consider what determines treatment success.***
Materials and methods: Retrospective review was performed of consecutive patients undergoing RLP between 2014-2022. Outcomes of interest included symptom relief, complication rates and renographic findings at follow-up. Treatment success was defined in terms of symptom improvement and/or improvement as well as relief of obstruction on renography.
Results: In total, 95 RLPs were performed in 54 women and 41 men, with a mean age of 40 years (IQR: 21-58). Flank pain was the most frequent presenting complaint (n = 81, 85%) followed by infection (n = 33, 35%). More than one indication for surgery was present in 1/3 of the patients. Urodynamic relevant obstruction on renography was found in 62 patients (65%) preoperatively. Mean operative time was 123 minutes (range 60-270). Two patients experienced minor intraoperative complications. At three months follow-up, 91% of patients had symptom relief, and no obstruction on renography was recorded in 64%. There was no significant association between improvement in symptoms and renography findings at follow-up, p = 1.
Conclusions: RLP can deliver a high success rate in terms of symptom relief and few complications. There was no association between renography findings and symptom relief at follow-up. Success after surgery should be determined by symptom relief rather than renography findings.

KEY WORDS: Robot assisted laparoscopic pyeloplasty; Ureteropelvic junction obstruction; Isotopic renography; Symptom relief; Complications.

Submitted 26 February 2024; Accepted 28 March 2024

INTRODUCTION

Ureteropelvic junction obstruction (UPJO) is a condition where the flow of urine from the renal pelvis to the ureter is impaired at the anatomical transition between the renal pelvis and proximal ureter (1). While most cases are congenital, other possible causes include kidney stone disease, urothelial neoplasms and as a result of inflammatory processes. Postoperative scarring and ischemia can also serve as precipitants. Congenital aetiologies encompass a range of possible causes, including physiological defects such as aperistaltic segments and anatomical factors such as the presence of crossing vessels (2). Moreover, UPJO is considered the most common congenital abnormality of the ureter (2). This particular impairment can lead to the development of hydronephrosis as well as a progressive deterioration in renal function (3). From a clinical perspective, the most common presenting complaint is intermittent abdominal or flank pain, which is often associated with an excess intake of fluid. This may also be accompanied by nausea and vomiting (2). The diagnosis can be subsequently confirmed through imaging modalities such as ultrasound and *computed tomography* (CT) urography (4). Additionally, isotopic renography is commonly used for diagnostic purposes, although consensus regarding the exact criteria for defining obstruction is lacking (5).
Symptomatic obstruction of the ureteropelvic junction should be treated surgically (6).
Indications for surgery include the presence of symptoms associated with the obstruction, a progressive impairment of renal function or infection in the upper urinary. Historically, the preferred surgical procedure has been dismembered pyeloplasty when intervention is warranted (2). Initially, open surgery was the sole option; however, advancements in surgical technology over recent decades have allowed for minimally invasive approaches, such as laparoscopic and robotic pyeloplasty, to now standard as the reference interventions (7).
Currently, *robotic assisted laparoscopic pyeloplasty* (RLP) is reported to yield success rates exceeding 90% (8-11). The robotic-assisted approach for pyeloplasty is further associated with short hospital stay and low complication rates (12). Consensus is also lacking regarding how treatment success should be defined.
At our institution, the *Da Vinci Robotic system* (*Intuitive Surgical, Sunnyvale, CA, USA*) is currently utilized in the surgical management of UPJO. In the present study, we aimed to evaluate the outcomes associated with RLP since beginning with this approach. In addition, we wanted to explore the relationship between the result of the follow

up isotopic renography in comparison to symptom improvement in order to better understand how treatment success should be defined.

Materials and methods

Study population and setting

Since 2014, RLP has been the standard treatment for UPJO at *Haukeland University Hospital*, a regional centre in Western Norway. Retrospective review of the electronic medical records was performed for consecutive patients undergoing RLP between 2014 and 2022. Outcomes of interest included symptom relief, complication rates and renographic findings at three months follow-up. Patient demographics and preoperative characteristics are shown in Table 1. The *American Society of Anesthesiologist* (ASA) score was used assessing the patient's general condition.

Indications for surgery included flank pain, infection, and impaired renal function. These indications did not change over the study period. An evaluation of the symptom burden was made by each urologist in consultation with the patient.

During the preoperative work up, all patients underwent imaging with ultrasonography and cross-sectional imaging such as CT. A preoperative nuclear scan (MAG3 diuretic renogram) was performed in order to determine split- and total renal function, as well as to assess the degree of obstruction. Urodynamic relevant obstruction was defined as no emptying of the renal pelvis within 15 minutes after intravenous administration of diuretics. Physiological obstruction was determined by delayed emptying of the renal pelvis within 15 minutes after diuretic administration. Serum creatinine and eGFR were measured both preoperatively and at follow-up.

Surgical procedure

The *Da Vinci Robotic Surgical System* was used to perform an Anderson-Hynes dismembered pyeloplasty with resection of excess renal pelvis and re-anastomosis to the ureter. A postoperative JJ-stent was routinely placed before completing the anastomosis and remained in place for four weeks before removal in the outpatient clinic. An abdominal drain at the conclusion of the surgery was placed at the surgeon´s discretion in the early procedures. Postoperative complications were assessed using the Clavien-Dindo grading system (13).

All patients were scheduled for follow-up at least three months postoperatively. The follow-up included repeat isotopic renography as well as consultation with a urologist. Further follow-up was repeated whenever deemed necessary by the surgeon, respectively 12 months postoperatively.

Treatment success

Treatment success was determined based on the following criteria:

1. *Patient-reported improvement*: Surgical success was categorised if patients reported a clinically significant improvement in their symptoms or complete symptom relief at the three-month follow-up assessment.
2. *Radiological assessment*: Radiological success was categorised as the absence of urodynamic relevant obstruction on isotopic renography conducted at least three months postoperatively.

Statistics

Independent samples t-tests were performed to compare continuous variables, such as renal split function and creatinine levels prior to surgery and at follow-up. Associations between categorical variables, i.e., symptom relief and findings at isotopic renography at follow-up, were assessed using exact chi-squared tests or Fischer´s exact tests. IBM SPSS Statistics 28 (*IBM, Armonk, NY*) was used for statistical analysis. The p-value was considered significant when < 0.05.

Ethics and approvals

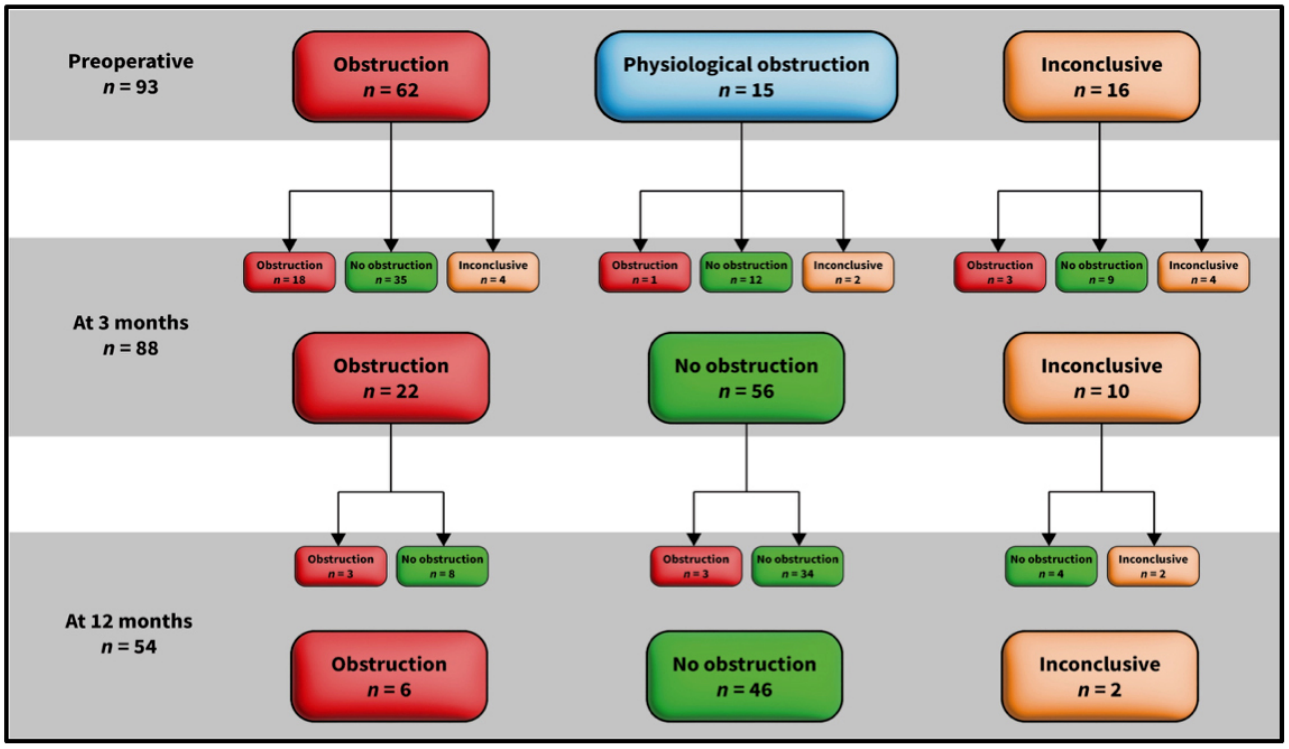
In accordance with institutional and Norwegian regulations, the study was registered as a clinical audit (eProtocol, project ID 3470) and as such, was exempted from further ethical approval.

Table 1.
Preoperative characteristics.

Characteristics		Numbers
Sex	Women	54 (57%)
	Men	41 (43%)
Age in years, mean (range, IQR)		40 (10-78, 21-58)
Side of surgery	Right	45 (47%)
	Left	50 (53%)
ASA-score	I	48 (51%)
	II	40 (42%)
	III	7 (7%)
Comorbidity [a]		21 (22%)
	Coronar disease	3 (3%)
	Hypertension	17 (18%)
	Congestive heart failure	1 (1%)
	Renal failure	4 (4%)
	Diabetes mellitus	5 (5%)
	Cancer	2 (2%)
	Anticoagulantia	2 (2%)
Weight in kg, mean (range, IQR)		75 (32-160, 62-87)
Serum Creatinine in mmol/L, mean (IQR)		81 (39-135, 64-90)
Isotopic renography		93 (98%)
	Urodynamic relevant obstruction	62 (67%)
	Functional/physiological obstruction	15 (16%)
	Inconclusive result	16 (17%)
Preoperative imaging [b]		95 (100%)
	Ultrasound	36 (38%)
	Non-contrast CT	36 (38%)
	Contrast enhanced CT	57 (60%)
	MRI	2 (2%)
Previous URS due to hydronephrosis		17 (18%)
	Diagnostic only	15 (16%)
	Treatment with balloon dilatation	2 (2%)
Drainage at the time of surgery		30 (32%)
	JJ-stent	17 (18%)
	Nephrostomy catheter	13 (14%)

[a] *Some patients had more than one comorbidity.*
[b] *In total, 38 patients (40%) had multiple modality preoperative imaging.*

Figure 1.
Renography findings – flowchart.



Results

Between April 2014 and December 2022, 95 RLP procedures were performed by five urologists. In total, 54 (57%) women and 41 (43%) men with a mean age of 40 years (IQR: 21-58) underwent surgery. Preoperative characteristics are provided in Table 1.

Flank pain was the most frequent cause of surgery (81 cases, 85%) followed by infection (33 cases, 35%) and impaired renal function (19 cases, 20%). In 32 patients (34%), more than one indication for surgery was present. An isotopic renography prior to surgery was performed in 93 patients (98%), and urodynamic relevant obstruction was found in 62 (67%). In the remaining 31 (33%), renography was inconclusive or revealed physiological obstruction only (Figure 1). There was no statistically significant association between flank pain and urodynamic relevant obstruction on preoperative isotopic renography, p = 0.35.

Anderson-Hynes pyeloplasty with re-anastomosis between the ureter and the renal pelvis was performed in all patients, except for one patient who underwent adhesiolysis around the ureteropelvic junction only. Antegrade JJ-stent was placed in all but two patients. In one of these cases, placement of the stent was unsuccessful, and a nephrostomy tube was inserted. In the other case, insertion of a JJ-stent was deemed unnecessary as no new anastomosis was made. An abdominal drain was placed at the end of the surgery in the first 11 patients undergoing RLP when the robotic approach was first started. In these cases, the drain was removed on the first postoperative day. For the latter 84 patients, no abdominal drain was placed. Details regarding the surgical procedures are listed in Table 2.

Intraoperative complications occurred in two patients (2%), both involved minor bleeding from either a tear in the renal parenchyma or the renal pelvis. The surgical procedures were successfully completed in both patients. Four patients (4%) developed post operative infection

Table 2.
The surgical procedure.

Characteristics	Numbers
Numbers of procedures per surgeon, total (%)	95 (100%)
A	41 (43%)
B	33 (35%)
C	11 (12%)
D	9 (9%)
E	1 (1%)
Antibiotic prophylaxis, number (percent)	61 (64%)
Bactrim	6 (10%)
Cefalotin	14 (23%)
Cefuroxim	26 (43%)
Other	15 (24%)
Cause of ureteropelvic obstruction	
Crossing vessels	61 (64%)
High inserting ureter	6 (6%)
Adhesions	14 (15%)
Renal malrotation	4 (4%)
Other	10 (11%)
Exit strategy: JJ-stent	93 (98%)
Time to stent removal in weeks, mean (range, IQR)	4 (2-9, 3-5)
Placement of abdominal drain	11 (12%)
Perioperative bleeding in ml, mean (range, IQR)	36 (0-200, 20-50)
Operative time in minutes, mean (range, IQR)	123 (60-270, 97-140)

Table 3.
Postoperative complications occurring within 3 months after surgery.

Characteristics	Numbers
Postoperative complications, number (%) [a]	19 (20%)
Infection	14(15%)
Pain	4 (4%)
Stent related problems	3 (3%)
Other [b]	3 (3%)
Postoperative complications requiring treatment	19 (20%)
at the outpatient clinic	11(12%)
and hospitalisation	8 (8%)

[a] *Some patients had more than one complication.*
[b] *One patient had dilation of the anastomosis. In another two patients the stent had retracted up in the ureter and had to be removed with ureteroscopy.*

during the hospital stay and one patient (1%) experienced postoperative pain before discharge beyond that expected. All the postoperative complications were categorised as Clavien-Dindo grade 1 or 2. Median post operative hospital stay was two days (IQR: 1-2).
Follow-up after three months with an isotope renography was registered in 88 cases (94%), and no obstruction was found in 56 cases (64%). In the remaining 32 patients (36%), 22 (25%) still had signs of urodynamic relevant obstruction and an additional 10 (11%) had inconclusive tests (Figure 1).
The renal split function did not change from the preoperative (right 51.1%/left 48.9%) to the three months follow up renography (right 51.1%/left 48.9%), p = 1. No difference was observed regarding serum-creatinine when preoperative blood analysis (85 mmol/L) was compared to blood test at follow-up (84 mmol/L), p = 0.5. The same result was found comparing GFR before and after surgery (82 mL/min and 83 mL/min, respectively), p = 0.7.
In total, 91% of all patients experienced complete resolution of their symptoms (n = 45) or reported overall symptom improvement (n = 33). Of note, 30 out of 32 patients with inconclusive renography findings or persistent urodynamic relevant obstruction after three months, nevertheless reported symptom free status (n = 14) or experienced overall improvement in their symptom burden (n = 16). There was no significant association between symptom improvement or becoming symptom free after surgery and the finding of no obstruction on follow-up isotopic renography, p = 1. Table 3 summarises postoperative complications occurring within the first three months after surgery.
A total of 54 patients (57%) underwent 12 months follow up including additional isotopic renography (Figure 1). No obstruction was registered in 46 patients (85%), and inconclusive findings in two patients (4%). Urodynamic obstruction was registered in six patients (11%). In three of these, signs of obstruction had appeared since the previous follow-up. Despite the renographic finding, all three experienced symptom resolution.
In 12 patients (71%) with urodynamic obstruction or inconclusive finding at three months follow-up, no obstruction was registered at the 12-month renography. Furthermore, 93 % of the patients experienced complete symptom resolution or reported an overall improvement in their symptoms at 12 months follow up. Patients with persistent obstruction after 12 months were planned for further follow-up with renography and endoscopic assessment whenever indicated. No patients needed re-pyeloplasty.

Discussion

In this study, we have examined the outcomes of RLP conducted at our institution over a period of nearly 8 years. Flank pain was the most frequent indication for surgery. However, more than one indication for surgery was identified in one third of the patients. Anderson-Hynes dismembered pyeloplasty was performed in all but one patient. In total, 91% of the patients reported resolution of their pain at follow-up. Two patients had minor intraoperative bleeding, which ultimately had no impact on completing the surgery. In addition, four patients experienced a post operative urinary infection and received antibiotic therapy. Our results align with previous research, which supports RLP as a safe procedure with a high success rate in terms of symptom relief and the complication burden (8, 9, 14, 15).
At three months follow-up, no obstruction on isotopic renography was found in 64% of the patients. In the remaining 36%, evidence of urodynamic relevant obstruction was either still present, or the test was inconclusive. Our radiological success rate is lower compared to other reports in the literature, which is likely attributable in part to variations in the definitions employed for renographic success (8, 15, 16). While we determined radiological success as the absence of urodynamic significant obstruction on renography three months after surgery, defined as no emptying of the renal pelvis within 15 minutes after intravenous administration of diuretics, *Etafy et al.* defined radiological success as a half-time (t½) isotope excretion of less than 10 minutes on diuretic renogram performed five to six weeks postoperatively (14). In that study, 82.5% of the patients were considered to be successfully treated based on the diuretic renogram (14). *Wood et al.* reported a success rate of 97.6% from a radiological perspective, with improvement or the arrest of deteriorating drainage, as the given criteria for success but with no further details (8). The lack of a common definition for treatment success after pyeloplasty thus makes it difficult to compare results across different studies.
In the present study, while flank pain was preoperatively reported in 81 cases, preoperative isotopic renography indicated urodynamic relevant obstruction in 62 cases only. Surprisingly, no statistically significant association between the presence of preoperative flank pain and detection of urodynamic relevant obstruction was found, p = 0.35. This might be explained by the strict definition for obstruction at renography used at our institution. On the other hand, patients may experience intermittent flank pain due to UPJO that may not be recognized as relevant obstruction in time periods with no symptoms. This may also explain why 30 of the 32 patients in our study displaying persistent urodynamic relevant obstruction or inconclusive findings at follow-up isotopic renography, reported symptom improvement or complete resolution.

Furthermore, although the obstruction is relieved by the surgery, persistent hydronephrosis due to a flaccid renal pelvis may cause delayed emptying and thereby mimic obstruction.

Although no association between obstruction on renography and symptom relief was found, renal split function before and after surgery may add information to the result of the surgery. In the present study, renal split function was unchanged between preoperative and follow-up tests, indicating that the surgery did not deteriorate the function of the affected kidney. Other author groups have also reported on the diagnostic value of split renal function when determining success after pyeloplasty (5, 15). The difficulty in defining obstruction at renography, and the finding of no association between symptoms and renographic obstruction in the present study, have led us to question the clinical role of isotopic renography in UPJO besides determining renal split function.

Previous studies have shown that RLP is associated with a markedly reduced postoperative hospital stay when compared to conventional laparoscopic pyeloplasty. This highlights the efficiency and potential benefits of adopting a robotic approach in the setting of urological procedures (17, 18). Our median inpatient stay was 2 days (IQR: 1-2), which is similar to findings from other studies (8, 14, 16, 19-21).

The present study has several limitations. The retrospective design may have impeded complete data collection for all patients. A few patients were lost to follow-up as they were referred from external centres and underwent follow up at their local hospital. Despite this, complete follow-up data was available for 94% of the patients, which is a strength of the study. The sample size is relatively small, but the vast majority of published series originate from nations with much larger populations.

The majority of patients (91%) reported either improvement or complete resolution of their symptoms at three months follow-up. However, no validated tool for subjective pain assessment was employed in this study. The assessment of preoperative symptoms and postoperative symptom relief was therefore based solely on patients´ individual accounts to the urologist and the documentation accordingly. This lack of standardisation is a clear limitation of the study but does reflect real world practice. While a lack of a standardised definition for urodynamic relevant obstruction on isotopic renography in the literature presents a further challenge when conducting research in this particular area, a definition was applied in this study that was implemented at our institution prior to the study start date and has remain unchanged over the whole period.

Conclusions

RLP can be performed with high success rates in terms of symptom relief and the morbidity profile. Of particular relevance to clinical practice is that this study highlights the disparity between renographic findings and symptom improvement. Of note, an absence of correlation between preoperative pain and isotopic renography findings was found, and there was no discernible link between renography results and symptom relief at follow-up. Therefore, we argue that defining treatment success should place a greater emphasis on symptom improvement rather than only relying on renography findings.

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Conflict of interest: The authors declare no potential conflict of interest.