Reconstruction of UPJ Obstruction

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1. Introduction

The ureteropelvic junction is the region of the ureter where the renal pelvis joins the proximal ureter. This is an area of the ureter more prone to problems likely due to factors related to embryology and blood supply. Causes of obstruction are multiple and reconstructive repair involve diverse techniques.[1,2]

1.1 Keywords

UPJ Obstruction, Pyeloplasty, Endopyelotomy

2. Definition

Ureteropelvic Junction (UPJ) obstruction refers to an internal or external obstruction where the renal pelvis and proximal ureter meet that can restrict urine flow.

3. Risk Factors and Pathophysiology

Table 1. Causes of UPJ Obstruction
Congenital
Aperistaltic/adynamic ureteral segment
Intrinsic stenosis
Ureteral valves
Lower pole accessory vessel/crossing vessel
High ureteral insertion with kinks
Adhesive bands
Acquired
Adhesive bands
Vesicoureteral reflux
Iatrogenic injury (e.g. ureteroscopy)
Malignant neoplasms
Benign neoplasms (fibroepithelial polyp)
Inflammation with scarring (retroperitoneal fibrosis, trauma, history of impacted urolithiasis)

Table 2. Symptoms and signs of UPJ Obstruction
Symptoms
Ipsilateral flank pain (often more pronounced with fluid or alcohol intake)
Abdominal pain
Intermittent pain associated with nausea vomiting
Nausea/vomiting
Gastrointestinal symptoms
Signs
Renal pelvis calculi
Hydronephrosis (without ipsilateral ureteronephrosis)
Urinary Tract Infection (UTI)
Reduced renal function
Elevated serum creatinine
Delayed kidney drainage on imaging

UPJ obstruction occurs more commonly in children than adults and males than females.[1] UPJ obstruction can result in increased pressure within the renal pelvis leading to renal damage and deterioration in renal function.[2,3] Anatomic causes of UPJ obstruction in adults may be due to **disease within the ureter** or from external compression.[4] Intrinsic disease of the ureter may be congenital such as an **aperistaltic ureteral segment or stricture**. A frequently found defect is the presence of an aperistaltic segment of ureter. Histopathologically, the spiral musculature normally present is replaced by abnormal longitudinal muscle bundles of fibrous tissue.

Ureteral disease resulting in UPJ obstruction may also be due to stricture from acquired causes such as **nephrolithiasis or iatrogenic stricture from endoscopic procedures**. Benign fibroepithelial polyps or malignancy such as transitional cell carcinoma can occur anywhere in the collecting system but can also be a cause of UPJ obstruction. Extrinsic disease of the ureter resulting in UPJ obstruction is most commonly due to a **crossing renal vessel**. Significant crossing vessels have been noted in up to 63% of cases of UPJ obstruction but as little as 20% of cases of normal kidneys. However, external compression from **retroperitoneal fibrosis or retroperitoneal tumors may** also result in UPJ obstruction (**Table 1**).

4. Epidemiology

The incidence of this condition is unknown. However, in 2000, 0.8/100,000 inpatient hospitalizations were related to surgery for UPJ obstruction.[1] The vast majority of inpatient UPJ obstruction surgery was performed in urban centers and more than half the patients were under 18 years of age.[1,5]

5. Diagnosis

Patients with UPJ obstruction can present with various symptoms including flank pain, hematuria, infection, urolithiasis, recurrent urinary tract infections, pyelonephritis or a history of Dietl's crisis (worsening of flank pain after hydration) (**Table 2**).[2,4] Patients may be asymptomatic and present with incidental hydronephrosis on renal imaging. In the adult population, it is important to distinguish when surgical intervention is indicated for UPJ obstruction as some patients can be safely observed.

6. Evaluation

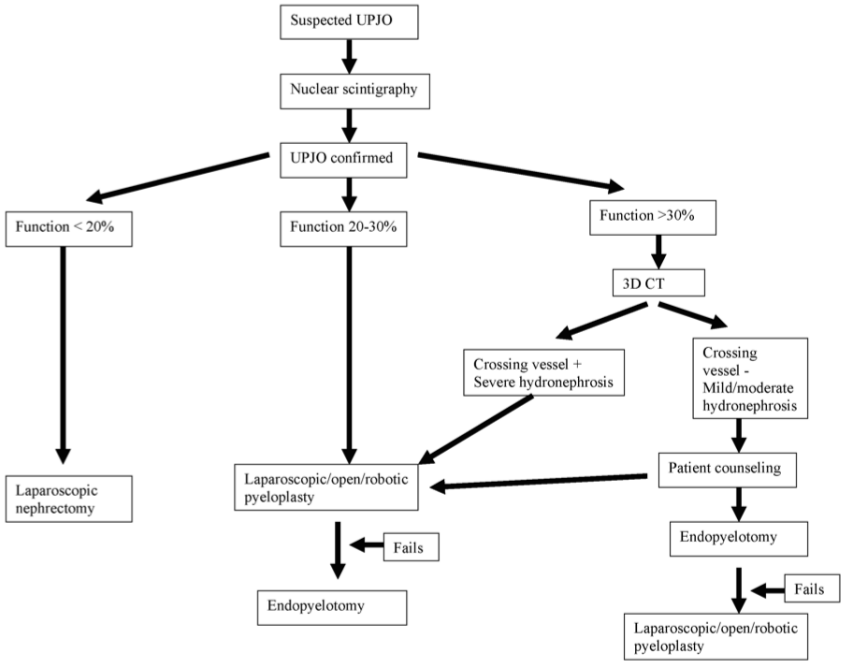

Figure 1: Algorithm for Surgical Treatment of UPJ Obstruction (From AUA Update Series 2007)

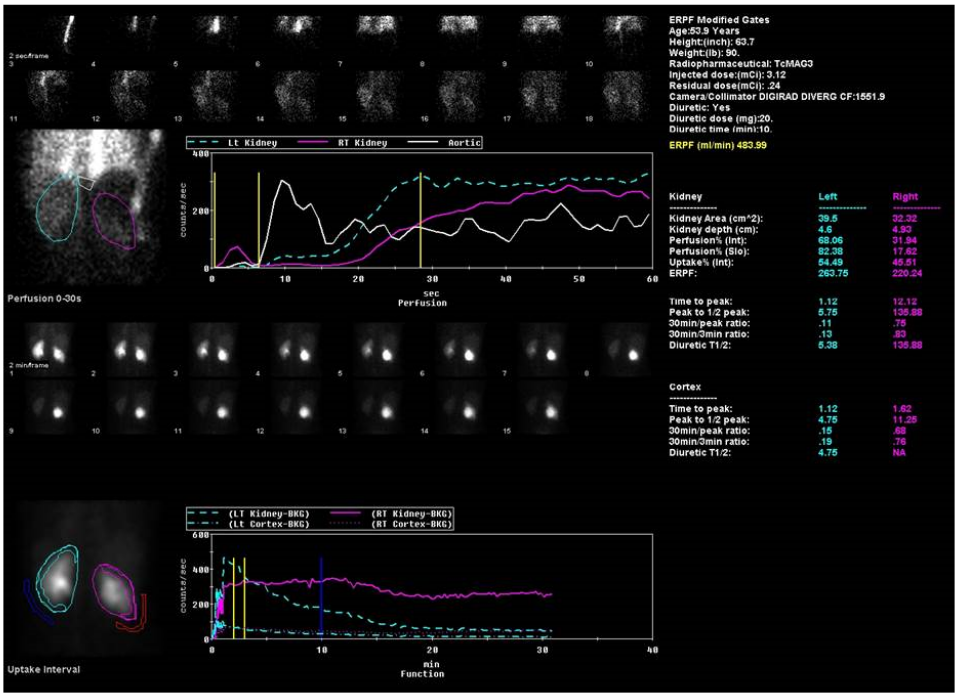

Figure 2: Abnormal MAG-3 with Delayed Drainage from the Right Kidney as well as Decreased Global Function in the Kidney

6.1 History and Physical Examination

Although typically congenital, UPJ obstruction can present clinically or incidentally at any time of life.

Work-up of UPJ obstruction begins with a history and physical examination. The patient history should include evaluation of episodes of flank pain and any associated fluid or alcohol intake around episodes of flank pain. History and symptoms associated with the flank pain that would point to a non-kidney source should be reviewed (pain worse with strenuous activity, history flank trauma, numbness and tingling in the extremities, pain radiating down the leg). Any history of urinary tract infections, nephrolithiasis, or hematuria should also be obtained. Risk factors for urothelial carcinoma should be elucidated. Likewise, past medical history should include comorbidities that may pose a risk to renal function (e.g. hypertension, diabetes). In thin patients and children with UPJ obstruction, a dilated renal pelvis may sometimes be palpated on physical examination (although this is not reliable).

6.2 Functional Evaluation

In order to determine if surgical intervention is warranted for UPJ obstruction, evaluation should confirm that a significant functional obstruction is present. Knowledge of differential renal function between the two kidneys and any presence of anatomic obstruction of the UPJ will help determine the appropriate surgical intervention. An algorithm for UPJ obstruction evaluation and subsequent treatment is demonstrated in **Figure 1.**[2]

A 99mTc-MAG-3 nuclear renal scan can help determine obstruction as well as assess for differential renal function and is preferred over 99mTc-DTPA.[2] In an appropriately hydrated patient, a diuretic half-time of < 10 min indicates no obstruction. A half-time of 10-20 minutes is equivocal, and prolonged half-time where the MAG-3 is not excreted within 20 minutes is suggestive of obstruction. Split renal function is determined by the amount of MAG-3 uptake in each kidney at a set time point after administration. **Figure 2 shows an abnormal Mag-3 with delayed drainage from the right kidney (Diuretic T1/2 135.9 minutes vs. 5.4 minutes for the left kidney) as well as decreased global function in the kidney (44.5% vs. 54.5% for the left kidney).**

Any ipsilateral ureterolithiasis should be treated prior to evaluation for UPJ obstruction. In cases of poor global renal function, the results of the MAG-3 study may not be clear. In that case, a Whitaker test to determine obstruction of flow from the kidney to the bladder may be performed.[6] The Whitaker test is performed by infusing fluid into the kidney through a nephrostomy tube and measuring the pressure difference between the renal pelvis and the bladder. This test should be performed with a foley catheter. **A renal pelvis/bladder pressure differential of < 13 cm of H2O is considered normal; 14-20 CM H2O is mild obstruction; 21-34 CM H2O is moderate obstruction; >35 cm H20 is severe obstruction.**

6.3 Anatomic Evaluation

A CT or MR Urogram can be helpful to provide functional and anatomic information. When reviewing cross-sectional imaging for UPJ obstruction, the surgeon should attempt to note the presence and appearance of the contralateral kidney, the degree of the hydronephrosis, the size and dilation of the renal pelvis, the level of insertion of the ureter into the pelvis, the caliber of the ureter distal to the

UPJ, the length and location of the stricture, and the presence of absence of a crossing vessel. It is also important to note the presence of urolithiasis. Though not always necessary, CT angiography may be performed to determine whether a crossing vessel is present, particularly in cases where management will change. It is critical to rule out malignant causes of obstruction which require a high index of suspicion as treatment options differ significantly. In cases where urothelial carcinoma is suspected, diagnostic ureteroscopy and retrograde pyelogram must be performed.

(see **Figure 1** and **Figure 2**)

Diagnostic ureteroscopy with retrograde ± antegrade pyelography is strongly recommended in the cases of secondary UPJ obstruction (iatrogenic injury, stricture following obstructed stone, failed primary repair) as the location, caliber, and length of the stricture can vary widely.

Cases in which the clinical cause of a patient's flank pain is unclear, the clinician should consider placement of a nephrostomy tube. The primary benefits of the nephrostomy tube are:

1. Antegrade studies or a Whitaker test can be performed
2. The pain can be triggered and relieved by capping and uncapping the nephrostomy tube
3. Allows symptom relief without the need of a ureteral stent which will allow for ureteral rest prior to reconstructive surgery

7. Treatment

7.1 Observation

Not all patients with UPJ obstruction require intervention.[7] Patients with an incidental finding of UPJ obstruction without any surgical indication may be observed. Indications for surgery include renal function compromise caused by functional obstruction, symptomatic obstruction, recurrent pyelonephritis, or symptomatic ipsilateral nephrolithiasis. Patients with asymptomatic stable nephrolithiasis can be monitored with plain film x-ray imaging (if visible) every 6-12 months. If stone growth is noted, treatment may be warranted.

7.2 Endopyelotomy

7.2.1 Indication

The endoscopic approach for treating UPJ obstruction (**endopyelotomy**) has been demonstrated to be effective as an initial or salvage procedure in select patients.[2,4] This approach has the advantage of reduced hospital stay and shorter recovery. Endopyelotomy involves cutting the stenotic, obstructed UPJ segment with either a cold knife, electrocautery or laser.[8] **Endopyelotomy may be performed through an antegrade or retrograde approach.**[8]

7.2.2 Operative Considerations

Endopyelotomy is a full-thickness incision (into per-ureteral fat) through the lateral aspect of the narrow ureter. It is considered a reasonable option in patients with mild to moderate hydronephrosis

and a short stricture. Patients who undergo endopyelotomy should have (i) renal function greater than 30% (ii) a stenotic segment less than 1.5 cm in length (iii) absence of a crossing vessel causing the obstruction, and (iv) absence of significant nephrolithiasis. An antegrade approach may be preferable if the patient is undergoing a concomitant percutaneous nephrolithotomy.

7.2.3 Outcomes

Success rates vary between 53-94%.[8] The long-term success of endopyelotomy has been questioned. The margin of success that pyeloplasty has over endopyelotomy may increase with time as pyeloplasty may be more durable.[8,,9]

7.2.4 Complications

These include recurrence of obstruction, infection and hemorrhage. Hemorrhagic complications range between 3-10%.[2,8] Infectious complications are under reported in the literature and occurred in 5% of patients in one series.[10] The AUA Best Practice Statement on antibiotic prophylaxis is a helpful guide.

7.3 Pyeloplasty

References	Study Type	Comparison (No.)	Results/Comment
Shalhav et al[21]	Retrospective	Antegrade (83) vs Acucise endopyelotomy (66)	• Retrograde endopyelotomy was less expensive with fewer complications • Antegrade endopyelotomy is preferred if there are concomitant stones or high ureteral insertion
el-Nahas et al[41]	Prospective randomized	Ureteroscopic laser (20) vs Acucise endopyelotomy (20)	• Retrograde endopyelotomy had a higher success rate • Both approaches had similar operating times and complication rates
Ost et al[50]	Retrospective	Laparoscopic pyeloplasty (50) vs antegrade endopyelotomy (50)	• Both approaches had equivalent surgical outcomes for primary UPJO • Laparoscopic pyeloplasty is favored for secondary UPJO and severe hydronephrosis
Desai et al[81]	Retrospective	Endopyeloplasty (15) vs antegrade endopyelotomy (15) vs laparoscopic pyeloplasty (14)	• Superior outcomes for laparoscopic pyeloplasty and endopyeloplasty compared to endopyelotomy • Endopyeloplasty had a shorter operative time than laparoscopic pyeloplasty
Bauer et al[61]	Retrospective	Open (35) vs laparoscopic pyeloplasty (42)	• Both approaches had equivalent success rates in relieving obstruction • Both approaches had similar morbidity and complications
Klingler et al[62]	Retrospective	Open (55) vs laparoscopic pyeloplasty (40)	• Both approaches had equivalent success rates in relieving obstruction • Morbidity lower in the laparoscopic group • Dismembered laparoscopic pyeloplasty had significantly better outcomes compared to Fengerplasty
Gettman et al[74]	Retrospective	Laparoscopic (6) vs robotic-assisted laparoscopic pyeloplasty (6)	• Both approaches had equivalent success rates • Suturing and operative times were shorter in the robotic group
Link et al[82]	Prospective non-randomized	Laparoscopic (10) vs robotic-assisted laparoscopic pyeloplasty (10)	• Both approaches had equivalent success rates • Robotic cases were more expensive

Table 3: Comparative Studies Between Different Surgical Approaches for UPJ Obstruction (From AUA Update Series 2007)

7.3.1 Indication

Indications for surgical intervention for UPJ obstruction include symptoms associated with obstruction, impairment of renal function, development of symptomatic stones or infection or causal hypertension.[11] Pyeloplasty has been shown to induce a reduction in systolic, diastolic, and mean arterial blood pressure.[12] Pyeloplasty is the most common surgical intervention for UPJ obstruction and should be performed in settings where endopyelotomy is contraindicated, such as obstruction from a crossing vessel and stenotic segments of obstruction that are greater than 1.5 cm in length.[2,4]

Pyeloplasty may also be considered as a primary treatment modality in patients where endopyelotomy is also indicated as some studies demonstrate improved durability with pyeloplasty.

7.3.2 Operative Considerations

Pyeloplasty has historically been performed with an open approach, but laparoscopic and robotic-assisted approaches are thought to produce success rates similar to open surgery with less blood loss, convalescence, and pain.[13,14] The advantage of minimally invasive approaches are less pronounced in children, but in adult patients, minimally invasive approaches have become more popular than open surgery for primary pyeloplasty.[14] Minimally invasive pyeloplasty can be approached via transperitoneal or retroperitoneal approach based on surgeon's preference.

Prior to proceeding with the dismembered pyeloplasty, the patient should ideally be without a ureteral stent for 4-6 weeks to minimize ureteral edema which may complicate the anastomosis. If the patient's symptoms are too severe to be stent free, a nephrostomy tube should strongly be considered.[15]

The dismembered pyeloplasty is the most common technique employed.[2] During a dismembered pyeloplasty, the colon is mobilized (a transmesenteric approach can sometimes be done in thin or pediatric patients) and the renal pelvis is exposed and dissected free from surrounding structures. The diseased/narrowed segment of UPJ is excised, the ureter and renal pelvis spatulated, and a running or interrupted anastomosis is performed. Alternatively, a flap pyeloplasty may be necessary for longer strictures not amenable to a dismembered pyeloplasty. In cases where a crossing vessel is not present, an in situ dismembered pyeloplasty has been described in which the lateral connection between the renal pelvis and proximal ureter remains intact.[16] A ureteral stent is typically placed but can be per surgeon preference.[14] Stent placement can be performed retrograde cystoscpically, or antegrade through a laparoscopic port or percutaneously via a 14 gauge angiographic catheter.

If the patient has a nephrostomy tube prior to surgery, its removal at the time of surgery is at the discretion of the surgeon. While the patient may prefer to have it removed, keeping the nephrostomy tube will allow for improved drainage in the case of a urine leak and the ability to obtain antegrade studies before or after stent removal. In cases of salvage procedures, it is recommended to leave the nephrostomy tube in until after stent removal.

With the advent of the DaVinci SP surgical system, single port robotic pyeloplasty has become more accessible.

In cases where ureteral tissue is very poor or the stricture length is significant (>3 cm), buccal mucosa grafts may be used for ureteral reconstruction.[17] his can be performed using either an onlay graft after incising the stricture or an augmented anastomotic repair in which the ureter was transected and reanastomosed primarily on one side, and a graft was placed on the other side. On right sided cases, appendix interposition can also be considered.[18]

7.3.3 Outcomes

Outcomes from selected endoscopic treatments as well as open, laparoscopic, and robotic-assisted

pyeloplasty procedures are compared in **Table 3.**

7.3.4 Complications

Recurrence of the UPJ obstruction is the most common and troublesome complication at a rate of **0-6%** in select series.[2] In addition, some series report even greater long-term failure rates.[19] Such patients may be amenable to endoscopic intervention, repeat pyeloplasty or ureterocalycostomy. Other complications include bowel injury, hemorrhage, urinoma, ileus, pneumonia which occur in 12-16% of patients.[11]

7.4 Ureterocalycostomy

7.4.1 Indication

Ureterocalycostomy may be performed when a UPJ obstruction occurs in the setting of a (i) small intrarenal pelvis (ii) to help ensure dependent drainage in a horseshoe kidney or (iii) as a salvage UPJ obstruction procedure.

7.4.2 Operative Considerations

Ideal anatomy for ureterocalycostomy would include thin lower pole parenchyma and lower pole hydronephrosis, thus enabling a limited partial nephrectomy and a wide bore mucosal anastomosis. The ureter is anastomosed over a stent directly to the lower pole calyx after the overlying parenchyma has been removed. This operation is typically considered when there is a scarred renal pelvis or an intrarenal pelvis. Likewise, this should only be considered when there is significant parenchymal thinning as to allow for adequate hemostasis following transection of the lower pole of the kidney.

7.4.3 Outcomes/Complications

Scant data exists on ureterocalycostomy.[20] Matlaga et al. reported on 11 patients over a 13-year period and noted no perioperative complications or long-term failures.[20]

7.5 Salvage Procedures

Salvage procedures following initial treatment failure for UPJ obstruction include redo-pyeloplasty, buccal graft pyeloplasty, and endopyelotomy. Surgical approaches for UPJ obstruction are compared in **Table 3**.

A redo-pyeloplasty should be considered for patients with crossing vessels, grade 3-4 hydronephrosis or impaired kidney function.[21] Redo-pyeloplasty is associated with longer operative times and large intra-operative blood loss. A recent multi-institutional study noted similar success rates between primary and secondary pyeloplasty, however, the secondary pyeloplasty group required a buccal graft in 35% of the cases.[17] While endopyelotomy is a reasonable salvage procedure following failed pyeloplasty, it has been shown to have worse outcomes compared to a redo-pyeloplasty.[22]

In cases of a poorly functioning kidney or significant medical comorbiditiy, a simple nephrectomy should be considered. If renal perseveration is mandatory, drastic salvage options include ureterocalycostomy, appendiceal interposition (if on the right side), bowel interposition (e.g. ileal ureter), or auto-transplantation.

8. Post-Operative Pathways

There is no agreed upon follow up after surgery for UPJ obstruction. If a stent is left in place, this is often removed around 4-6 weeks after surgery.

If a nephrostomy tube was placed prior to surgery, it may be removed at the time of surgery at surgeon's discretion. It may also be left in place and capped for 4-6 weeks following surgery to allow for an antegrade nephrostogram following stent removal. If a urine leak develops post-operatively, the nephrostomy tube should be uncapped to allow for maximal drainage.

Patients are often followed with regular ultrasounds to evaluate for hydronephrosis. This can lead to confusion as chronically dilated collecting systems may not return to normal. Some have advocated routine use of postoperative Mag-3 studies. The benefit of functional post-operative imaging is the ability to follow split renal function and an objective measure of drainage. However, its utility is unclear if the imaging study will not change management. [23]

9. Costs

Based on data from the Urologic Diseases of America Project, inpatient hospitalizations related to UPJ obstruction surgery cost an estimated $11.7 million in year 2000.[1] Between 1999 and 2003, the average cost per child hospitalized with primary diagnosis of UPJ obstruction was $7,728.[1]

10. Clinical Care Pathway

A suggested algorithm for approach to and treatment of UPJ obstruction is demonstrated in **Figure 1.**[2]

11. Abbreviations

MAG-3 = Mercaptoacetyltriglycine
UPJ = ureteropelvic junction obstruction

12. Podcasts

Crossfire in Urology-Robotic Reconstruction (March 10, 2021)

Videos

V909

Robot-assisted laparoscopic single-port pyeloplasty in children using the da Vinci SP® system

Single Port Robotic Pyeloplasty: Similar Outcomes, Excellent Cosmesis

Presentations

Reconstruction of UPJ Obstruction Presentation 1

References

☆ † Lam, JS, Breda, A, Schulam, PG: Ureteropelvic junction obstruction. J Urol 2007; 177: 1652.

1 Significant epidemiologic data on UJP obstruction from the Urologic Diseases in American Project. Study combined multiple data sources to produce important estimates of disease burden and cost

☆ † Desai, M, Hegarty N: Contemporary Surgical Management of Adult Ureteropelvic Junction Obstruction. AUA Update Series 2007; 26: 54.

2 Excellent review from the AUA update serious that summarizes surgical management of adult UPJ obstruction.

3 ☆ Waterman B, Jerde T, Nakada SY Ureteral Physiology: Implications in Urological Practice. AUA Update Series 2006; 25: 154.

† Nakada SY, Hsu T:: Management of Upper Urinary Tract Obstruction. In: Campbell-Walsh Urology 10th Edition, pp. 1122-1168, 2011.

4 Comprehensive and detailed chapter on the topic of UPJ obstruction. Excellent illustrations and photos.

5 Wolf, J. Stuart, Jr: Transperitoneal Laparoscopic Pyelplasty.

6 Jaffe, RB, Middleton, AW, Jr.: Whitaker test: differentiation of obstructive from nonobstructive uropathy. AJR Am J Roentgenol 1980; 134: 9.

7 ☆ Kinn, AC: Ureteropelvic junction obstruction: long-term followup of adults with and without surgical treatment. J Urol 2000; 164: 652.

8 Yong, D, Albala, DM: Endopyelotomy in the age of laparoscopic and robotic-assisted pyeloplasty. Curr Urol Rep 2010; 11: 74.

9 Dimarco, DS, Gettman, MT, McGee, SM et al.: Long-term success of antegrade endopyelotomy compared with pyeloplasty at a single institution. J Endourol 2006; 20: 707.

10 ☆ Conlin MJ, Bagley DH. Ureteroscopic endopyelotomy at a single setting. J Urol. 1998 Mar;159(3):727-31.

11 Nakada S, Best S.(2016) Management of Upper Tract Urinary Obstruction. Campbell and Walsh Urology 11th ed. Chapter 49.

12 Al-Mashhadi A, Häggman M, Läckgren G, Ladjevardi S, Nevéus T, Stenberg A, Persson AEG, Carlström M. Changes of arterial pressure following relief of obstruction in adults with hydronephrosis. Ups J Med Sci. 2018 Dec;123(4):216-224. doi: 10.1080/03009734.2018.1521890. Epub 2018 Oct 8. PMID: 30293474; PMCID: PMC6327611.

13 Strother MC, Mucksavage P. Minimally Invasive Techniques for the Management of Adult UPJ Obstruction. Curr Urol Rep. 2016 May;17(5):39

14 † Autorino R, Eden C et. al. Robot-assisted and laparoscopic repair of ureteropelvic junction obstruction: a systematic review and meta-analysis. Eur Urol. 2014 Feb;65(2):430-52

Excellent meta-analysis of minimally invasive pyeloplasty in adults and children.

15 Lee Z, Lee M, Lee R, et al. Ureteral Rest is Associated With Improved Outcomes in Patients Undergoing Robotic Ureteral Reconstruction of Proximal and Middle Ureteral Strictures. Urology. 2021;152:160-166. doi:10.1016/j.urology.2021.01.058

16 Aminsharifi A, Molaie A, Monsef A. Laparoscopic In Situ Dismembered Pyeloplasty Can Facilitate Laparoscopic Ureteropelvic Junction Obstruction Repair: A Prospective Cohort Trial. J Endourol. 2018 Mar;32(3):218-222. doi: 10.1089/end.2017.0538. Epub 2017 Dec 12. PMID: 29084479.

17 ☆ Lee M, Lee Z, Strauss D, Jun MS, Koster H, Asghar AM, Lee R, Chao B, Cheng N, Ahmed M, Lovallo G, Munver R, Zhao LC, Stifelman MD, Eun DD; Collaborative of Reconstructive Robotic Ureteral Surgery (CORRUS). Multi-institutional Experience Comparing Outcomes of Adult Patients Undergoing Secondary Versus Primary Robotic Pyeloplasty. Urology. 2020 Nov;145:275-280. doi: 10.1016/j.urology.2020.07.008. Epub 2020 Jul 18. PMID: 32687842.

18 Jie Wang, Shengwei Xiong, Shubo Fan, Kunlin Yang, Bingwei Huang, Dengxiang Zhang, Hongjian Zhu, Mingfei Ji, Jie Chen, Jiantao Sun, Peng Zhang, and Xuesong Li Appendiceal Onlay Flap Ureteroplasty for the Treatment of Complex Ureteral Strictures: Initial Experience of Nine Patients Journal of Endourology 2020 34:8, 874-881. https://doi.org/10.1089/end.2020.0176

19 J Endourol. 2006 Oct;20(10):707-12. Long-term success of antegrade endopyelotomy compared with pyeloplasty at a single institution.

20 Matlaga, BR, Shah, OD, Singh, D et al.: Ureterocalicostomy: a contemporary experience. Urology 2005; 65: 42.

21 Ekin RG, Celik O, Ilbey YO. An up-to-date overview of minimally invasive treatment methods in ureteropelvic junction obstruction. Cent European J Urol. 2015;68(2):245-51. doi: 10.5173/ceju.2015.543. Epub 2015 Jun 18. PMID: 26251754; PMCID: PMC4526614.

22 Crivelli JJ, Johnson BA, Steinberg RL, et al. Clinical and radiographic outcomes following salvage intervention for ureteropelvic junction obstruction. Int Braz J Urol. 2021;47(6):1209-1218. doi:10.1590/S1677-5538.IBJU.2021.0303

23 Faure A, London K, Smith GH Early MAG-3 diuretic renography results after pyeloplasty. BJU Int. 2016 Apr 22. doi: 10.1111/bju.13512. [Epub ahead of print]