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Surgical Approaches to Pediatric Ureteropelvic Junction Obstruction

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Abstract Approximately 10–30 % of infants with hydronephrosis are found to have ureteropelvic junction (UPJ) obstruction. Technological advances in imaging have allowed physicians to better identify the location of the obstruction. The classic repair is the Anderson-Hynes repair which shows a 90–100 % success rate and appears superior to many less complex techniques. Is it best to approach this repair through an open incision or laparoscopically with or without a surgical robot? That question remains to be answered and largely depends on how you define "best."

Keywords Hydronephrosis · UPJ obstruction · Imaging · Pediatric urology

Introduction

Hydronephrosis is the most common urological abnormality identified on infant ultrasound, occurring as often as 1 % [1]. This is now the most common presentation of ureteropelvic junction obstruction, transitioning from the presentation of a palpable renal mass in the newborn prior to the ultrasound era [2]. With increasing frequency, fetal MRI has been used to characterize this anomaly prior to birth. Early on, any dilation in the absence of reflux was considered secondary to obstruction and warranted surgical repair. The evolution of nuclear renography has provided clarity (and controversy) to this diagnosis. With the aid of retrograde pyelography, nuances to the interpretation of nuclear renography and magnetic resonance urography, the presence or absence of ureteropelvic junction obstruction can be argued with a wealth of information to support the surgeon's convictions (Figure 1).

Despite some controversy in diagnosis, there is general consensus that hydronephrosis proximal to the ureteropelvic junction in the setting of renal colic, decreasing differential renal function, and increasing hydronephrosis represents ureteropelvic junction obstruction. Fortunately, controversy in diagnosis is not the focus of this article, but how to manage the obstruction once the diagnosis is made.

Background

The most common etiology for infant hydronephrosis is ureteropelvic junction (UPJ) obstruction which accounts for approximately 2.5/100,000 hospitalization per year [3, 4, 5•]. The majority of the hospitalizations occur in children less than 3 years old [6]. The incidence of UPJ obstruction in those found to have hydronephrosis in infancy is 10–30 % [7]; this incidence increases in children with other urological abnormalities including horseshoe kidney, of which approximately 17 % of have UPJ obstruction [8]. The incidence of a crossing vessel causing extrinsic compression on the UPJ has been shown to vary from 15 to 52 % [9, 10]. The variation in the etiology of the obstruction has led to an evolution of repairs to correct the stricture and restore or preserve renal function. Different techniques have their advantages and

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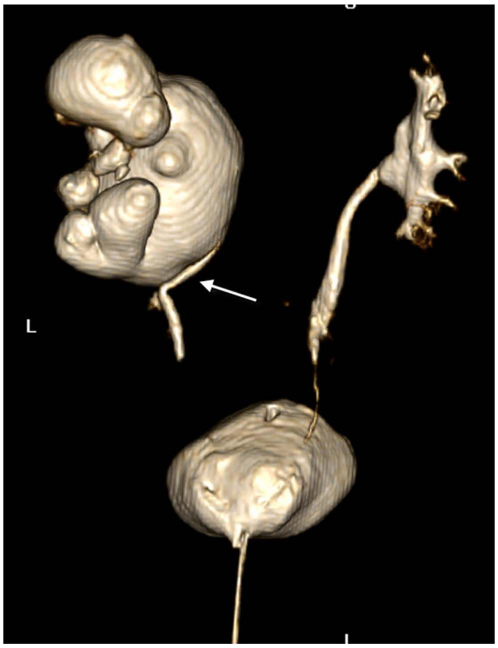

Fig. 1 Magnetic resonance urography (*MRU*): Excellent anatomic definition of a left ureteropelvic junction obstruction. Note the angulation of the proximal ureter with high insertion of the ureter into the renal pelvis (*white arrow*)

disadvantages as they relate to the child's anatomy and intraoperative findings.

Evolution of Repair

In 1939, the Foley Y-V plasty for UPJ obstruction was introduced. This was created for the high-insertion ureter and involves bringing the apex of the Y-flap of the pelvis to the most distal point of the incision along the ureter. During this repair, there is no discontinuity of the ureter from the pelvis, so the approach is somewhat inflexible in that it does not allow treatment of obstruction in the setting of a crossing renal vessel, and the ultimate position of the apex of the anastomosis is affected by the location of the original ureteropelvic junction. Although this approach has fallen from favor, Nerli et al. recently reported this repair to be safe and effective in a small population in which a tension-free anastomosis could not be completed [11].

In 1943, another approach was introduced which was very useful for those ureters with extensive adhesions or when they seemed to be too narrow and the proximal ureter cannot be bridged with a flap. This approach, known as the Davis intubated ureterotomy, involves opening the ureter with a spiral flap at the pelvis allowing for a closure over a ureteral stent. The flap is again brought down as far as possible, but does not reach the most distal point of the incised ureter and allows for healing of the ureter by secondary intention. This technique is generally augmented by a nephrostomy tube to minimize urinary extravasation and to facilitate healing of the regenerating ureter. Due to a high rate of stricture, this technique has largely been abandoned.

The most commonly used repair, even today, is the Anderson-Hynes dismembered pyeloplasty, described in 1949. This was a bold innovation in which the entire stenotic segment of the ureter was excised, dismembering the continuity of vascularity. The advantages of this approach are the definitive removal of the abnormal tissue, the ability to transpose a crossing vessel if indicated, and the flexibility to approach the repair from multiple angles (flank, posterior lumbotomy, subcostal), allowing the same principles to be performed using minimally invasive techniques [12]. Historically, the Anderson-Hynes repair has shown success rates between 85 and 90 % and is considered by many to be the "gold standard" for UPJ obstruction repair [13].

A shift toward minimally invasive surgery spawned an endoscopic approach utilizing either retrograde or antegrade ureteroscopy to incise the ureteropelvic junction. This was introduced by Arthur Smith in 1984 and popularized by Ralph Clayman in the 1990's [14]. The repair was then stented much like the Davis ureterostomy to allow healing by secondary intention. A fluoroscopically controlled cutting wire (Acucise) was developed to perform the procedure without direct visualization, and other techniques to dilate the ureteropelvic junction have also been described. Balloon dilation or endoburst therapy is a less elegant modification, but success rates are in the 60–80 % range, despite short-term follow-up and rare renal scan assessment [15]. Unique complications of hemorrhage, arteriovenous malformation, and ureteral necrosis have dampened initial enthusiasm for these approaches. Although there are still champions of these approaches, later studies have not been able to reproduce the initially high rate of success described, and these techniques have found their home as an option for salvage after failed pyeloplasty. In 2005, Weikert et al. retrospectively reviewed the use of Acucise endopyelotomy in a group of 24 patients with a mean follow-up time of 32 months. They identified a 58 % success rate, substantially lower than previously reported success rates approaching 80 % [16–20]. These numbers are significantly inferior to the open or laparoscopic repair of UPJ obstruction [21–23] (Table 1).

Advancing the goal of minimally invasive surgery, the first successful laparoscopic pyeloplasty was performed in 1993 [8, 24, 25]. The procedure generally employs the Anderson-Hynes technique, but has been described laparoscopically using retroperitoneal and transperitoneal approaches. Given its similarity in technique, there is no surprise that over time, the success rates of either the laparoscopic or open approach have been documented at 90 % with this method [26]. In a review of the National Surgical Quality Improvement Program from 2006 to 2011, there was an overall (pediatric and adult) increase in laparoscopic pyeloplasty procedures from 3 to 83 %. In adults, the open pyeloplasty was associated with an increase in the

Table 1 Studies comparing success rates of UPJ obstruction treatment modalities

Author	Year	Number	Type of repair	Success rate (%)
Kim et al.	1998	77	Acucise endopyelotomy	78
Braga et al.	2007	18	Secondary endopyelotomy	39
Braga et al.	2007	14	Secondary pyeloplasty	100
Penn et al.	2010	20	Lap pyeloplasty	100
Penn et al.	2010	19	Open pyeloplasty	95
Lindgren et al.	2012	16	Robotic pyeloplasty	100
Vannahme et al.	2014	24	Secondary endopyelotomy	44
Vannahme et al.	2014	34	Secondary pyeloplasty	87

reoperation rate and postoperative morbidity compared to the minimally invasive group [27]. Laparoscopy has provided the benefit of better magnification, but this approach does come with a steep learning curve in suturing techniques and tissue manipulation leading to longer operative times [28, 29]. The suture techniques prove to be especially difficult in children due to smaller tissue and limited abdominal space available for instrument manipulation. We have identified several technical steps in our practice which we feel maximize the efficiency of the laparoscopic approach (Table 2).

The most recent modification has been the debut of the robot. Significant advancements have been made in the area of the robotic-assisted approach to laparoscopic pyeloplasty, especially in children 6 months–1 year of age [30, 31]. The Perspective database analyzed ICD codes looking at open versus laparoscopic approaches to pyeloplasty repairs from 2003 to 2010. There was noted to be an increase in the number of laparoscopic procedures (including classic laparoscopic and robotic assisted) compared to those completed in an open manner, but without any change in hospital stay or complications. This did result in an increase of approximately $3500 per patient, mostly due to the costs of the robotic supplies [32]. In contrast, Bansal found that the 9 patients with a median age of 9 months who underwent robotic repair had significantly shorter hospital stays, less narcotic use, and 100 % success rate [30]. Lindgren showed that with a robotic approach to redo pyeloplasty in 13 children who had a history of a prior failed pyeloplasty, 100 % received symptomatic improvement and 88 % were shown to have radiographic improvement. The robot offers the ability to perform more precise movements as opposed to the traditional laparoscopic approach and may be embraced by a larger population of surgeons [33].

Table 2 Technical steps to improve efficiency with laparoscopic pyeloplasty

- 3-mm stab incisions to accommodate working instruments without ports
- Approach repair through a mesenteric window when feasible
- Transcutaneous traction sutures to free up instruments from retracting
- Avoid complete dismemberment until the anastomosis is begun to avoid unnecessary distraction of tissues while beginning the sutured repair
- Running anastomosis with double-armed absorbable suture
- No pre-stenting—The ureteral double J stent is placed antegrade over a wire through a stab incision after one half of the anastomosis is completed
- In males, flexible cystoscopy at case completion without repositioning validates bladder position of the distal stent coil and allows adjustment if necessary
- In females, inspection of the urethra validates no urethral stent migration

Complications

Documented complications from open or laparoscopic/robotic pyeloplasty include stricture recurrence, devascularization, urine leak, fistula formation, and persistent obstructions [34]. The incidence of persistent obstruction or anastomotic stricture is documented to be between 2 and 6 % [35, 36]. Delicate dissection of the periureteral tissues and creation of a tension-free repair are ways to minimize complications related to the procedure. Excessive manipulation compromises distal ureteral blood flow and subsequent healing. Another concerning complication is a urinoma due to a persistent leak at the site of ureteral anastomosis. Urine leaks cause intense inflammatory reaction, increasing the risk of breakdown or fibrosis of the repair [35, 36]. These complications apply to both the laparoscopic/robotic and open approach. Laparoscopic/robotic repair did have a greater chance of bowel injury, although this approximates only 1 % [19].

Long-term complications including declining renal function, hypertension, and proteinuria were evaluated by Lee et al. Analysis of 55 patients who were followed for a mean of 17 years, with 10 years of minimum follow-up, showed the presence of preoperative symptoms and elevated serum creatinine correlated with a diagnosis of hypertension by 20 years of age. Eighteen percent were found to have proteinuria ranging from 1+ to 3+. There was significant improvement in differential renal function from 35 to 40 % along with a significant decrease in hydronephrosis postoperatively, but there was found to be an increase in serum creatinine levels in these patients as well. An increase in creatinine from 0.9 to 1.1 in the HTN group and from 0.8 to 1.0 in the proteinuria group has been noted, although this may not represent a clinically significant change. The authors recommended evaluating for signs of functional renal compromise yearly for 10 years post-operatively, then every 5 until 20 years of age [37]. Long-term complications as they relate to the type of surgical repair have not been investigated.

To Stent or not to Stent

There is debate on the need for ureteral stenting at the time of the procedure to decrease complication rates. A study from Elmalik et al. from 2007 retrospectively reviewed their pyeloplasties from 1994 to 1998 (without stent) and from 1999 to 2003 (with stent). The average age of repair was about 6 years old. They noted that those stented had significantly shorter hospital stays (2.7 vs 4.3 days). The increased length of stay in the unstented group was due prolonged observation or intervention for anastomotic leak. It was also noted in this study that those who were stented noticed improvements in hydronephrosis to their new baseline nearly a year earlier than those who were not stented (3 vs 15 months). Overall complication rates did not differ between the groups, but they did differ in the types of complications noted. Those who did not receive a stent developed anastomotic leaks and clot obstruction versus those who were stented who developed urinary tract infection, calculi, and stent migration [38]. This study is challenged by Kim et al. who reviewed records from 64 children with unilateral UPJ obstruction. They did not note any differences between the groups regarding overall postoperative complications or resolution of hydronephrosis [39•]. Smith et al. and Siddique et al. both documented in their studies no differences in complication rates between groups which were stented versus non-stented [40, 41]. With the varying findings in the literature between stenting vs not stenting, it ultimately remains the preference and comfort of the performing surgeon. There is a similar discussion with minimal literature to support either method in regard to placing a perinephric drain for postoperative monitoring of urine leak.

Reoperative Pyeloplasty

When looking at stricture recurrence and treatment, both endoscopic and open techniques have been utilized. Braga et al. retrospectively reviewed 32 patients undergoing redo treatment of their failed primary repair. Of these, 18 were treated endoscopically with 40 % success rate and 14 were treated with redo pyeloplasty with 100 % success rate. Stricture length >1 cm and age <4 were associated with failure of an endopyelotomy [42••].

Other studies have identified the laparoscopic repair as an effective means of treating recurrent strictures with 100 % symptomatic relief and 88 % radiographic resolution. None of these cases required reoperation with a mean follow-up of 15 months [33]. Another contemporary series of primary failed pyeloplasty compared pyeloplasty to endopyelotomy. This series showed a success rate of 87.5 % with pyeloplasty compared to 44 % for an endopyelotomy [43]. There appears to be a clear benefit of pyeloplasty over endopyelotomy in the event of failed primary repair.

Decision-Making and Looking Forward

At present, the open, laparoscopic, and robotic repairs have been described with failure rates in the single digits. With the learning curve behind us, operating time is converging and complication rates are similar as well. Adult studies have emphasized that an increase in intraoperative time and expense translates to more rapid recovery and shorter hospitalization, but those differences have not been demonstrated in children. In their preliminary results of a randomized, prospective clinical trial comparing open to laparoscopic pyeloplasty, there was no significant difference in operating time, length of hospitalization, cost, or success rate [44••]. As mentioned above, the additional costs associated with the robotic approach have not dissipated with time. In the current era, the approach to operative pyeloplasty does not have a clear champion. This results in somewhat of a “dealer’s choice” approach to repair with surgeons choosing what they prefer.

With similar success, recovery and complication rates, our most influential outcome measures have shifted to cost and esthetics. In our evolving healthcare market with increasing accountability for cost containment, the cost of the robotic approach may not be justified. Although referring to the robotic approach to radical prostatectomy, an advisor to President Obama described the robotic approach as “a fake innovation that the Affordable Health Care Act will not reward” [45]. This leads us to believe that the excess cost associated with robotic approach may not be justified in the new healthcare laws.

The use of the robot in training centers, however, seems to be well entrenched. The ability to capture movement data in both simulation and actual surgery to be used as an objective metric for resident training and proficiency is an attractive tool that has been sorely absent since the advent of laparoscopy [46]. The increase in robotic experience at the expense of training in classic laparoscopy reduces exposure to classic laparoscopic skill development resulting in less proficient laparoscopic surgeons coming out of residency training. Although a clear benefit to robotic-assisted laparoscopic pyeloplasty has not been demonstrated, it does offer the benefit of a more rapid learning curve than classic laparoscopy in inexperienced hands, so may be a more efficient training strategy [47]. Given the steep learning curve associated with classic laparoscopy, the shift in training away from this to robotic assistance, and the difficulty maintaining this "pure laparoscopy" skill set, the robot may be the ultimate solution for the "occasional laparoscopist." The growing availability of a surgical robot to nearly every community suggests that the landslide of minimally invasive pyeloplasty from classic laparoscopic to robotic will continue [48]. The question remains, how much is too much and who is paying?

With regard to esthetics, it is clear that the public clamors for things small when it comes to incisional scars. Airplane magazines, billboards, and radio ads all promote the allure of near scarless surgery. In a more objective assessment, Autorino found that families preferred smaller scars, but only when it is safe and efficacious [49]. With a growing body of acronyms including HIdES, NOTES, and LESS [50–52], these innovations to minimize the apparent scars are here to stay. In regard to the pyeloplasty, the decision for families is made between a single 2–3-cm incision versus 3–4 puncture sites around the child's abdomen. Regardless of the repair, results are shown to be similar [44••].

Conclusion

Over the years, multiple modalities and techniques have been applied to treatment of ureteropelvic junction obstruction. Reviewing the different types of repairs, the basic or modified Anderson-Hynes approach of dismemberment shows lower rates of recurrence and higher rates of renal function improvement. There are nuances to drain management during the procedure which have not been definitively shown to be superior to one another. The rise in robotic and minimally invasive surgery reflects a patient and family desire for more cosmetic results. Studies have shown there is no champion when comparing the robotic, laparoscopic, or open repair. Despite this, there has been a dramatic rise in laparoscopic repairs in both the adult and pediatric population. It will be interesting to see with the new generation of health care reforms if popular, expensive, and well-marketed modalities without objective benefit will be covered by health care plans. We continue to leave the option of laparoscopic or open repair to the family, but all cases receive a ureteral stent with or without a perinephric drain.

Compliance with Ethics Guidelines

Conflict of Interest Ryan W. Tubre and John M. Gatti each declare no potential conflicts of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

References

Papers of particular interest, published recently, have been highlighted as:
- • Of importance
- •• Of major importance

1. Lee RS, Borer JG. Perinatal urology. Campbell-Walsh Urology e4. Ch 114, 3048–3066.
2. Vogt BA and Dell KM. The kidney and urinary tract of the neonate. Fanaroff and Martin's Neonatal-Perinatal Medicine, Chp 101, 1676–1699.
3. Chandrasekharam VV, Srinivas M, Bal CS, Gupta AK, Agarwala S, Mitra DK, et al. Functional outcome after pyeloplasty for unilateral symptomatic hydronephrosis. Pediatr Surg Int. 2001;17:524–7.
4. Kato Y, Yamataka A, Okazaki T, Yanai T, Lane GJ, Kobayashi H, et al. Surgical treatment and outcome of megahydronephrosis due to PUJ stenosis. Pediatr Surg Int. 2006;22:911–3.
5.• Knoedler J, Han L, Granberg C, Kramer S, Chow G, et al. Population-based comparison of laparoscopic and open pyeloplasty in paediatric pelvi-ureteric junction obstruction. BJU Int. 2013;111:1141–7. *This is a recent article showing that complication rates between open and laparoscopic repairs are similar.*
6. Schulam P. Chapter 9. Ureteropelvic junction obstruction. In: Litwin MS, Saigal CS, editors. Urologic Diseases in America US Department of Health and Human Services, Public Health Service, National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases. Washington, DC: US Government Printing Office; 2007. p. 323–32.
7. Garg R, Menon P, Rao K, Arora S, Batra Y. Pyeloplasty for hydronephrosis: issues of double J stent versus nephrostomy tube as drainage technique. J Indian Assoc Pediatr Surg. 2015;20(1):32–6.
8. Kavoussi LR, Peters CA. Laparoscopic pyeloplasty. J Urol. 1993;150:1891–4.
9. Marshall L, Lowe FC, Marshall SF. Ureteropelvic junction obstruction in adults. Urology. 1984;23:331–5.
10. Stephens FD. Ureterovascular hydronephrosis and the "aberrant" renal vessels. J Urol. 1982;128:984–7.
11. Nerli RB, Reddy MN, Jali SM, Hiremath MB. Preliminary experience with laparoscopic Foley's YV plasty for ureteropelvic junction obstruction in children. J Minim Access Surg. 2014;10(2):72–5.
12. Braga LH, Lorenzo AJ, Bagli DJ, et al. Comparison of flank, dorsal lumbotomy and laparoscopic approaches for dismembered pyeloplasty in children older than 3 years with ureteropelvic junction obstruction. J Urol. 2010;183(1):306–11.
13. Seo IY, Oh TH, Lee JW. Long-term follow-up results of laparoscopic pyeloplasty. Korean J Urol. 2014;55(10):656–9.
14. Smith AD. Percutaneous ureteral surgery and stenting. Urology. 1984;23:37–42.
15. Webber RJ, Pandian SS, McClinton S, Hussey J. Retrograde balloon dilatation for pelviureter junction obstruction: long-term follow-up. J Endourol. 1997;11(4):239–42.
16. Weikert S, Christoph F, Muller M, Schostak M, Miller K, Schrader M. Acucise endopyelotomy: a technique with limited efficacy for primary ureteropelvic junction obstruction in adults. Int J Urol. 2005;12(10):864–8.
17. Nakada SY. Acucise endopyelotomy. Urology. 2000;55:277–82.
18. Kim FJ, Herrell SD, Jahoda AE, Albala DM. Complications of acucise endopyelotomy. J Endourol. 1998;12:433–6.
19. Preminger GM, Clayman RV, Nakada SY, et al. A multicenter clinical trial investigating the use of a fluoroscopically controlled cutting balloon catheter for the management of ureteral and ureteropelvic junction obstruction. J Urol. 1997;157:1625–9.

20. Shalhav AL, Giusti G, Elbahnasy M, et al. Adult endopyelotomy: impact of etiology and antegrade versus retrograde approach on outcome. J Urol. 1998;160:685–9.
21. Gill HS, Liao JC. Pelvi-ureteric junction obstruction treated with acucise retrograde endopyelotomy. Br J Urol. 1998;82:8–11.
22. Biyani CS, Minhas S, el Cast J, Almond DJ, Cooksey G, Hetherington JW. The role of acucise endopyelotomy in the treatment of ureteropelvic junction obstruction. Eur Urol. 2002;41:305–10. **discussion 10–11**.
23. Sharma SK, Klopukh BV, Turk TM. Long term study of the efficacy of acucise endopyelotomy for primary and secondary UPJ obstruction. J Urol. 2003;169:24. **(Abstract) 95**.
24. Schuessler WW, Grune MT, Tecuanhuey LV, et al. Laparoscopic dismembered pyeloplasty. J Urol. 1993;150:1795–9.
25. Piaggio LA, Franc-Guimond J, Noh PH, et al. Transperitoneal laparoscopic pyeloplasty for primary repair of ureteropelvic junction obstruction in infants and children: comparison with open surgery. J Urol. 2007;178:1579–83.
26. O'Reilly PH, Brooman PJ, Mak S, et al. The long-term results of Anderson-Hynes pyeloplasty. BJU Int. 2001;87:287–9.
27. Oberlin DT, McGuire BB, Pilecki M, et al. Contemporary national surgical outcomes in the treatment of ureteropelvic junction obstruction. Urology. 2015;85(2):363–7.
28. Ravish IR, Nerli RB, Reddy MN, et al. Laparoscopic pyeloplasty compared with open pyeloplasty in children. J Endourol. 2007;21:897–902.
29. Bansal D, Cost NG, Bean CM, et al. Infant robot-assisted laparoscopic upper urinary tract reconstructive surgery. J Pediatr Urol. 2014;10(5):869–74.
30. Bansal D, Cost NG, DeFoor WR, et al. Infant robotic pyeloplasty: comparison with an open cohort. J Pediatr Urol. 2014;10:380–5.
31. Reddy MN, Nerli RB. The laparoscopic pyeloplasty: is there a role in the age of robotics? Urol Clin North Am. 2015;42(1):43–52.
32. Varda BK, Johnson EK, et al. National trends of perioperative outcomes and costs or open, laparoscopic and robotic pediatric population. J Urol. 2014;191:1090–6.
33. Lindgren BW, Hagerty J, et al. Robot-assisted laparoscopic reoperative repair for failed pyeloplasty in children: a safe and highly effective treatment option. J Urol. 2012;188:932–7.
34. McNeil BK, Flanigan RC. Complications of open renal surgery. Complications Urol Surg Pract 2007. Pp 65–80.
35. Lim DJ, Walker III RD. Management of the failed pyeloplasty. J Urol. 1996;156:738–40.
36. Inagaki T et al. Laparoscopic pyeloplasty: current status. BJU Int. 2005;95 Suppl 2:102–5.
37. Lee HE, Park K, Choi H. An analysis of long-term occurrence of renal complications following pediatric pyeloplasty. J Pediatr Urol. 2014;10(6):1083–8.
38. Elmalik K, Chowdhury MM, Capps SNJ. Ureteric stents in pyeloplasty: a help or a hindrance? J Pediatr Urol. 2008;4:275–9.
39.• Kim J, Sungchan P, Hwang H, Kim JW, Cheon SH, Park S, et al. Comparison of surgical outcomes between dismembered pyeloplasty with or without ureteral stenting in children with ureteropelvic junction obstruction. Korean J Urol. 2012;53:564–8. *This articles challenges earlier articles which showed the need for ureteral stent placement at the time of repair.*
40. Smith KE, Holmes N, Lieb JI, et al. Stented versus nonstented pediatric pyeloplasty: a modern series and review of the literature. J Urol. 2002;168:1127–30.
41. Siddique M, Pansota MS, Saleem MS, Attique-ur-Rehman. Outcome of pyeloplasty in children. J Ayub Med Coll Abbottabad 2014;26(1).
42.•• Braga LHP, Lorenzo AJ, et al. Failed pyeloplasty in children: comparative analysis of retrograde endopyelotomy versus redo pyeloplasty. J Urol. 2007;178:2571–5. *This is a good article that compares endopyelotomy to pyeloplasty. The results are very favorable for performing a pyeloplasty, even in those that fail a primary repair.*
43. Vannahme M, Mathur S, Davenport K, Timoney AG, Keeley Jr FX. The management of secondary pelvi-ureteric junction obstruction—a comparison of pyeloplasty and endopyelotomy. BJU Int. 2014;113(1):108–12.
44.•• Penn HA, Gatti JM, Hoestje SM, DeMarco RT, Snyder CL, Murphy JP. Laparoscopic versus open pyeloplasty in children: preliminary report of a prospective randomized trial. J Urol. 2010;184(2):690–5. *This is a prospective randomized trial comparing laparoscopic vs open dismembered pyeloplasty with 39 pediatric patients.*
45. Albertson P. Robotic vs open RP: who pays the cost? Urologytimes.com. September 2012. Vol 40. No 10.
46. Lee JY, Mucksavage P, Kerbl DC, Huynh VB, Etafy M, McDougall EM. Validation study of a virtual reality robotic simulator—role as an assessment tool? J Urol. 2012;187(3):998–1002.
47. Passerotti CC, Passerotti AM, Dall'Oglio MF, Leite KR, Nunes RL, Srougi M, et al. Comparing the quality of the suture anastomosis and the learning curves associated with performing open, freehand, and robotic-assisted laparoscopic pyeloplasty in a swine animal model. J Am Coll Surg. 2009;208(4):576–86.
48. Duchene DA, Rossa F, Clayman R, McDougall EM, Winfield HN. Current minimally invasive practice patterns among postgraduate urologists. J Endourol. 2011;25(11):1797–804.
49. Autorino R, White WM, Gettman MT, Khalifeh A, De Sio M, Lima E, et al. Public perception of "scarless" surgery: a critical analysis of the literature. Urology. 2012;80(3):495–502.
50. Gargollo PC. Hidden incision endoscopic surgery, description of technique, parental satisfaction and applications. J Urol. 2011;185(4):1425–31.
51. Kilbansky D, Rothstein RI. Robotics in endoscopy. Curr Opin Gastroenterol. 2012;28(5):477–82.
52. Zygomalas A, Kehagias I, Giokas K, Koutsouris D. Miniature surgical robots in the era of notes and less: dream or reality? Surg Innov. 2015;22(1):97–107.