Modified Dismembered Technique of Laparoscopic Transperitoneal Pyeloplasty in Children

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Abstract

Background: Laparoscopic pyeloplasty in children gained more and more popularity over the past two decades. However, it remains technically challenging with the most steps of the procedure are ureteric spatulation, DJ insertion, and intracorporeal anastomosis. Many modifications have been proposed to address these issues. In this article, we present our surgical approach to laparoscopic transperitoneal modified dismembered pyeloplasty highlighting some tips to make it easy.

Objectives: This study was conducted to evaluate the outcomes of laparoscopic management of ureteropelvic junction obstruction children.

Patients and Methods: This was a prospective study carried out on patients who presented with UPJO to our center from May 2019 to October 2021. All the cases underwent laparoscopic transperitoneal modified dismembered pyeloplasty where complete dismembering is deferred after the ureteropelvic anastomosis to prevent ureteral torsion and to use the redundant pelvis as a handle for ureteric manipulation. We used 3 simple techniques for antegrade insertion of DJ.

Results: The study included 25 patients (19 males and 6 females) The mean age at operation was 30.88 ± 27.48 months. The mean time needed for the anastomosis was 80 minutes while the mean total operative time was 155 minutes. No conversion was needed. Apart from 2 cases, all other patients showed significant improvement of the degree of hydronephrosis and renal split function.

Conclusion: The described modifications facilitated performing the procedure rendering laparoscopic pyeloplasty to be a less demanding and much easier procedure than the conventional technique.

Keywords: Pyeloplasty; Laparoscopy; UPJO; Endourology.

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Introduction

Over the past two decades, laparoscopic pyeloplasty (LP) has gained more and more popularity and become the method of choice for the surgical correction of ureteropelvic junction obstruction (UPJO) by many authors **(Turrà et al., 2016)**. Its success rate is greater than 95% which is equivalent to that of the open procedure with the added value of being minimally invasive, more magnification, less pain, early post-operative recovery, minimal wound complications and better cosmesis **(Leonardo et al., 2020)**.

Despite many advancements, LP in children is still a technically challenging operation that many urologists simply do not feel comfortable with due to the advanced suturing skills required **(Giannakopoulos et al., 2012)**. The most difficult, time-consuming, and critical steps of the procedure are ureteric spatulation, double J (DJ) insertion, and intracorporeal ureteropelvic anastomosis. Many modifications have been proposed to address these issues **(Rizkala et al., 2010, Cascio et al., 2012.,)** In this article, we present our early experience with laparoscopic transperitoneal dismembered pyeloplasty with description of our modified approach to help with these difficult steps.

Patients and Methods

This was a prospective study carried out on patients who presented with UPJO to to the Pediatric Surgery Department at El-Chatby University Children's Hospital during the period from May 2019 to October 2021. The sample size was calculated using G Power 3.1.9.4, 2018. Based on an effect size of 0.6, alpha error of 0.05, power of 80%, the minimum required sample size was calculated to be 24 patients. The sample size was rounded to be 25 patients **(Fernández-Ibieta et al., 2016)**.

Preoperative evaluation

Preoperative evaluation included routine laboratory investigations, an ultrasound (US) at least two times (under similar circumstances considering fluid intake and bladder filling) to confirm hydronephrosis and exclude megaureter, and a diuretic renogram: Tc99m diethylenetriamine penta-acetic acid (DTPA): to assess differential renal function (DRF). Voiding cystourethrogram (VCUG) was performed to exclude vesicoureteric reflux (VUR) in cases with bilateral hydronephrosis, if the referring reason was febrile urinary tract infections (UTI) or if there is any ureteral dilatation. The indications for surgical intervention were differential function of less than 40%, an obstructed curve on renogram with T1/2 longer than 20 minutes, severe calyceal dilatation with anteroposterior renal pelvic diameter (APRPD) > 30mm, worsening hydronephrosis on follow up US, cortical thickness of less than 3 mm and cases with clinical symptoms attributable to UPJO as loin pain or recurrent febrile UTI. Cases of redo pyeloplasty, bilateral UPJO, or associated bladder or ureteric problems were excluded **(Gopal et al., 2019)**.

Surgical technique

The patient is positioned at the operating table's edge in a modified lateral decubitus position at a 30-40^o elevation of the affected side with a silicon roll placed under the renal angle. The surgeon stood on the opposite side of the UPJO with the cameraman on his left hand in left side cases and on his right hand in right side cases **(Rivas et al., 2013)**. We used a three-trocar approach to the abdomen for laparoscopic pyeloplasty. The first trocar was placed at the umbilicus, the second one was placed in the midline midway between the xyphoid process and the umbilicus and, the third one was placed above and medial to the anterior superior iliac spine in the ipsilateral iliac fossa. The location of this port is critical as it should be aligned with the anastomosis to facilitate suturing. Generally, triangulation should be the target with respect to the renal pelvis.

The operative steps are conducted in the following order (**Fig. 1**):

1) Exposure of UPJ

For a retrocolic approach, the white line of Toldt is incised from the colic flexure to the iliac vessels. The ureter is retracted laterally, and the gonadal vein is retracted medially. A transmesenteric approach can be used when a large, dilated pelvis is bulging through the colonic mesentery on the left side. After proper dissection and exposure of UPJ, the anteromedial aspect of the renal pelvis is stitched with a percutaneous hitch stitch (Prolene 2/0). The ureter is then dissected caudally for about 3-5 cm.

2) UPJ incision and ureteric spatulation

The renal pelvis is incised at the most dependent point from its lower angle below the UPJ, leaving a portion of the redundant dilated pelvis in continuity with the ureter to be used as a handle during ureteric manipulation (**Yang et al., 2015**). The scissors were inserted through the supraumbilical port to be in line with the long axis of the ureter facilitating its spatulation. A small transverse incision is made below the narrow segment. One pair of scissors was inserted into the ureteric incision, and spatulation was done of its posterolateral aspect for at least 1.5 to 2 cm (**Giannakopoulos et al., 2012**).

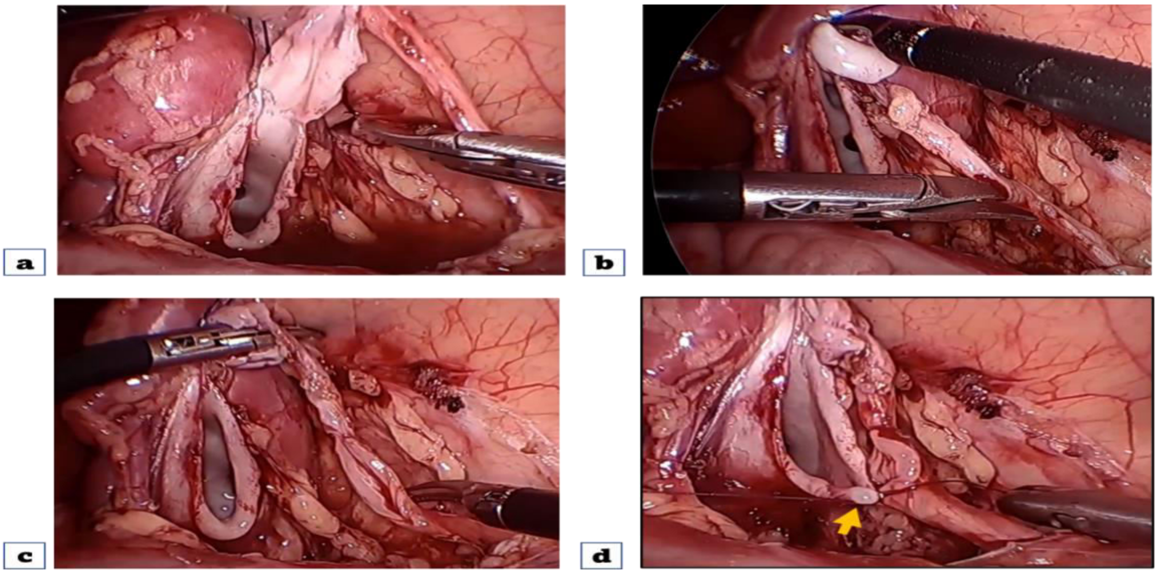

Fig. 1 A case of left pyeloplasty **(a)** Incision of the renal pelvis below the UPJ at the most dependent point leavening the upper part still attached to the renal pelvis. **(b)** Spatulation of the ureter: the scissors was introduced through the epigastric port. One branch of the scissors is inserted into the ureteric lumen after a small transverse incision was made. (**c**) Sufficient spatulation is performed on its posterolateral aspect for about 1.5 cm while handling the ureter using the part which will be excised later.

(d) The first suture creating the lower angle (yellow arrow) is placed before the ureter and pelvis are completely dismembered.

3) Posterior wall of the anastomosis

We used polyglactin 5/0 suture (Vicryl®) on a round-tip 13-mm needle for ureteropelvic anastomosis. The needle is introduced either through the port (after slight straightening), through the port incision after the port has been removed, or percutaneously. The first and the most important suture to create the lower angle is placed between the most dependent point of the pelvis to avoid any windsock effect or kinking and the angle on posterolateral side of the spatulated ureter. To tie the knots extraluminally, the suture was started from outside the pelvis to inside the ureter on the right side, and from outside the ureter to inside the pelvis on the left side. To avoid purse string effect, another suture is added on both sides of the first suture. After that, a suture is positioned on the posterior wall, tied extraluminally, and the needle is brought into the inside of the renal pelvis. With the needle now on the inside, a continuous suture is used to complete the posterior wall.

4) Stenting

At this point, a ureteric stent was inserted **(Elmalik et al., 2008)**. We noted that direct introduction of the guide wire and trying to manipulate it to the ureter using grasper was difficult and sometime the wire was bent by the grasper, and we had to change it with a new one. To overcome that, we adopted three tricks for DJ insertion that made it easy:

a) A 50 mL syringe needle is inserted below the costal margin at a level that allows the guidewire to be introduced parallel to the ureter. The guidewire is advanced into the bladder through the ureter. Then, the needle is removed, and a DJ stent is introduced over the guidewire. **(Fig. 2).**

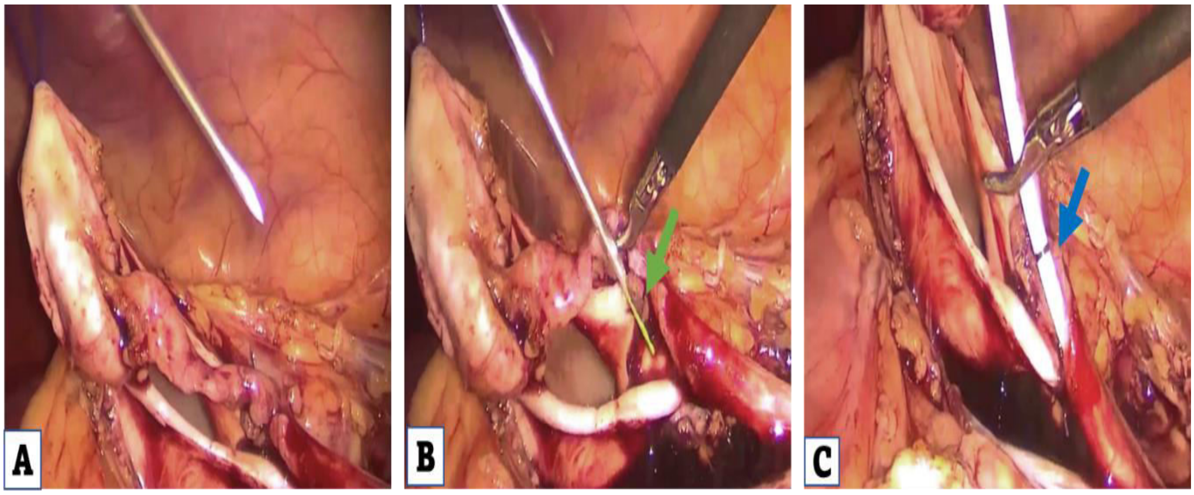

Fig. 2 Stent insertion using a 50 mL syringe needle. A: The needle is inserted below the costal margin to be parallel to the ureter. B: The guidewire (green arrow) is introduced into the ureter. C: After removal of the needle, the DJ stent is introduced over the guidewire (blue arrow).

b) The DJ pusher is introduced through the epigastric incision after port removal with gentle compression around it to prevent gas leakage. The pusher is semirigid and can be manipulated from the outside while fixing the ureter with a grasper through the other port until the pusher enters the ureter. The guidewire is introduced down the ureter and then a DJ stent is advanced over it.

c) The suction instrument is inserted through the subcostal port and positioned opposite the ureteric incision. A guidewire is introduced through its lumen down into the ureter. The guidewire was introduced down the ureter and then a DJ stent was advanced over it. (**Fig. 3**). The position of the stent into the bladder was confirmed by free efflux of urine or by C-arm. The renal pelvis is then flushed with saline using the suction-irrigator before the anastomosis is completed to remove any residual blood clots that may obstruct the DJ catheter.

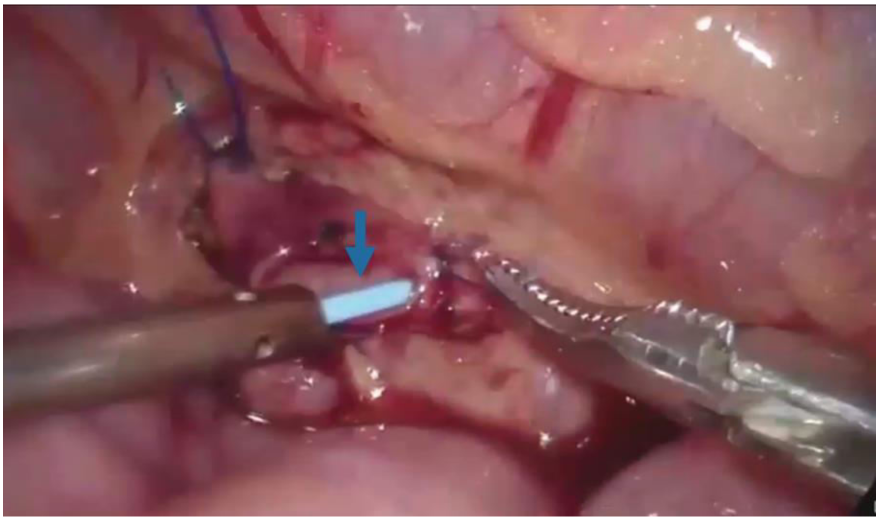

Fig. 3 Stent insertion using the suction instrument which is inserted through the subcostal port, positioned opposite the ureteric incision and the DJ with the guidewire are introduced through its lumen down into the ureter.

5) ***Anterior wall of the anastomosis and pyelotomy closure***

Another suture was used to finish the anterior anastomosis in a continuous fashion. Dismembering was then completed with trimming of the redundant renal pelvis from its remaining attachment to the pelvis and the ureter. Then, the renal pelvis was closed with a continuous suture. The resected UPJ specimen is removed via one of the working ports. After releasing the percutaneous Hitch stitch, the ureter and UPJ are properly oriented. The field is irrigated with saline and suctioned. Under direct visualization, a drain is introduced from the lower port and positioned posterior to the proximal ureter.

Postoperative follow-up

Oral feeding was initiated on the same day 6 hours postoperatively after full recovery from anesthesia. The urinary catheter was removed after 24 hours, and the drain was removed when its output ceased. The DJ stent was removed by cystoscopy after 6-8 weeks postoperatively. Follow up US are scheduled at 3, 6, 9 and 12 months post-operatively. Renal function was re-assessed using a DTPA renography, 1 year after surgery **(Fernández-Ibieta et al., 2016)**.

Statistical analysis

The collected data was wrangled, coded, and analyzed using the SPSS software (Armonk, NY: IBM Corp version 25.0). The quantitative variables were expressed using mean ±SD whereas counts were presented in number (%). A chi-square test was used to estimate the difference between the categorical variables. Wilcoxon test and Friedmann test were used to determine the change pre and postoperatively and Mann-Whitney test was used to determine the difference between groups. Statistical significance was considered when $p<0.05$.

Results

During the study period, 32 patients underwent laparoscopic pyeloplasty at the Pediatric Surgery Department at El-Chatby University Children's Hospital. Seven cases were excluded from the study; one case lost follow up and the other 6 cases having a crossing polar vessel; one of them underwent laparoscopic vascular hitch while the other 5 have conventional dismembered pyeloplasty with transposition of the proximal ureter and renal pelvis anterior to the vessel (**Fig. 4**).

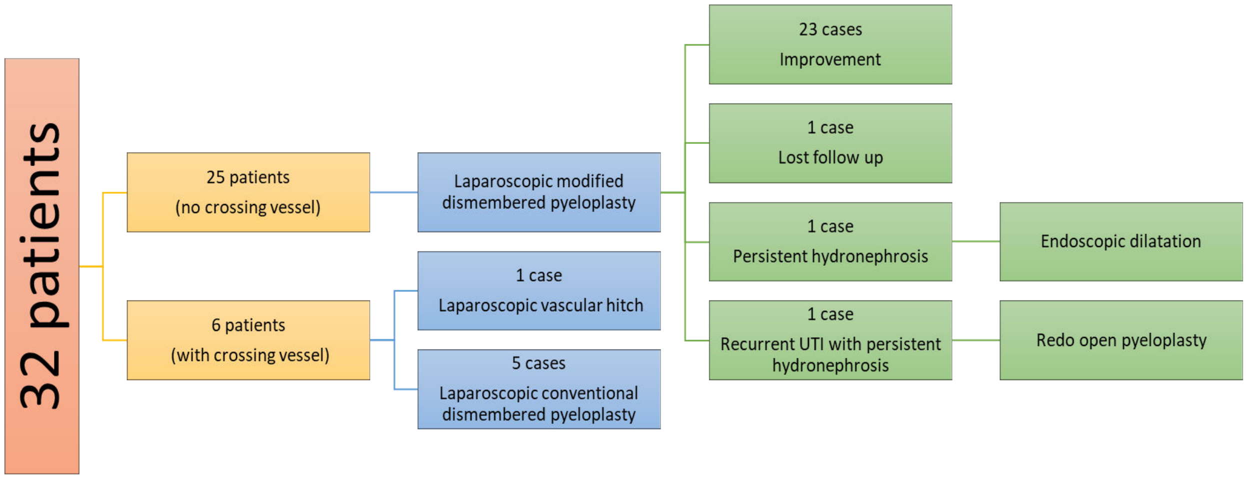

Fig. 4. A flow chart of the cases included in the study

The study included 19 males and 6 females. The mean age at operation was 30.88 ± 27.48 months (range, 4 – 110 months). The average weight was 14.56 kg (range, 5 – 37 kg). In 13 cases, the left kidney was affected (52%) while in the other 12 cases, the right kidney was affected (48%). The majority of cases (72%) were asymptomatic and diagnosed incidentally with US being performed for nonspecific complaints. 3 cases were detected antenatally (12%) while 3 other cases were complaining of recurrent severe loin pain (12%) with Only one case presented with recurrent UTIs.

All cases underwent laparoscopic transperitoneal pyeloplasty. In 19 cases, we used a retrocolic approach. In the other 6 cases, the renal pelvis was dilated and bulging through the mesentery of the colon where we used a transmesocolic approach. We used 3 ports except in 3 cases with right UPJO where a fourth port was required for liver retraction.

The time needed for the anastomosis ranged from 50 – 130 minutes (mean 80 minutes) while the total operative time ranged from 100 – 220 minutes (mean 155 minutes) (**Table 1**). The mean operative time with retrocolic approach was shorter than with transmesocolic cases but without statistical significance. The time required for DJ insertion ranged from 3 – 15 minutes (mean 8 minutes) without significant difference between insertion techniques. All cases were completed laparoscopically without conversion to open surgery. There were no operative complications.

Table 1. Operative details of the studied patients

Operative time (minutes)		
Mean ± SD	155.2 ± 32.8	
Median (Min. – Max.)	160.0 (100.0 – 220.0)	
Retrocolic Mean ± SD Median (Min. – Max.)	 147.37 ± 24.46 150.0 (110.0 – 190.0)	U= 27.5, p= 0.059*
Transmesocolic Mean ± SD Median (Min. – Max.)	 180.0 ± 45.17 195.0 (100.0 – 220.0)	
Anastomosis time (minutes)		
Mean ± SD	80.0 ± 22.3	
Median (Min. – Max.)	80.0 (50.0 – 130.0)	
Hospital stay (days)		
Mean ± SD	1.96 ± 1.84	
Median (Min. – Max.)	2.0 (1.0 – 10.0)	

SD; Standard deviation, U; Mann-Whitney test, *; Significant ($p<0.05$)

The mean hospital stay was 1.96 ± 1.84 days (range 1- 4 days). The amount of fluid came in the drain was insignificant with a mean of 32 ± 17 SD ml of serosanguineous fluid. The mean period for drain removal was 3.92 ± 1.78 days (range 2 - 6 days). The mean period of analgesia withdrawal was on the 6th ± 2 SD postoperative day.

Postoperative complications were encountered in 2 patients (8%) requiring reintervention. In both cases, we performed a retrocolic dismembered pyeloplasty and both were eventless without any difficulties. The first case showed persistent hydronephrosis after DJ removal. The case was followed for a month and the hydronephrosis was progressive. Endoscopic dilatation was done with insertion of a new DJ. The new DJ was removed after one month and there was gradual resolution of the hydronephrosis on follow up US. The other case showed recurrent UTIs with radiological evidence of obstruction at the new UPJ. Open redo pyeloplasty was done 3 months after removal of DJ from the first operation.

The postoperative outcomes are represented in (**Table 2**). The mean APRPD of the patients was 35.08 ± 13.44 mm preoperatively, 26.56 ± 9.97 mm after 3 months, 23.92 ± 9.59 mm after 6 months 20.46 ± 6.57 mm after 9 months and it became 18.04 ± 6.06 mm after 12 months (**Fig. 5**). The difference was statistically significant ($p<0.001$). The mean cortical thickness increased from 6.86 ± 3.03 mm preoperatively to 11.7 ± 2.57 mm after 12 months follow up (**Fig. 6**). This improvement was statistically significant ($p< 0.001$).

Table 2. Postoperative morphological and functional outcomes

Variables	Pre- operative	Post-operative (1 Year)	Test of significance (p)
APRPD			$\chi 2$= 73.259, p< 0.001*
Mean ± SD	31.08 ± 13.44	16.04 ± 12.06	
Median (Min. – Max.)	28 (18 – 60)	15.5 (6 – 27)	
Cortical thickness			Z= -4.21, p< 0.001*
Mean ± SD	6.86 ± 3.03	11.7 ± 2.57	
Median (Min. – Max.)	6.5 (2.0 – 15.0)	12.0 (8.0 – 20.0)	
Split function			Z= -3.73, p< 0.001*
Mean ± SD	42.08 ± 7.93	44.95 ± 5.9	
Median (Min. – Max.)	45.0 (15.0 – 49.0)	47.5 (25.0 – 50.0)	
Tracer clearance			Z= -4.37, p< 0.001*
Mean ± SD	26.16 ± 8.3	75.84 ± 9.93	
Median (Min. – Max.)	25.0 (14.0 – 40.0)	75.0 (55.0 – 92.0)	

$\chi 2$: Friedmann test, pairwise comparison was done; Z; Wilcoxon test; SD; Standard deviation, *; Significant (p<0.05)

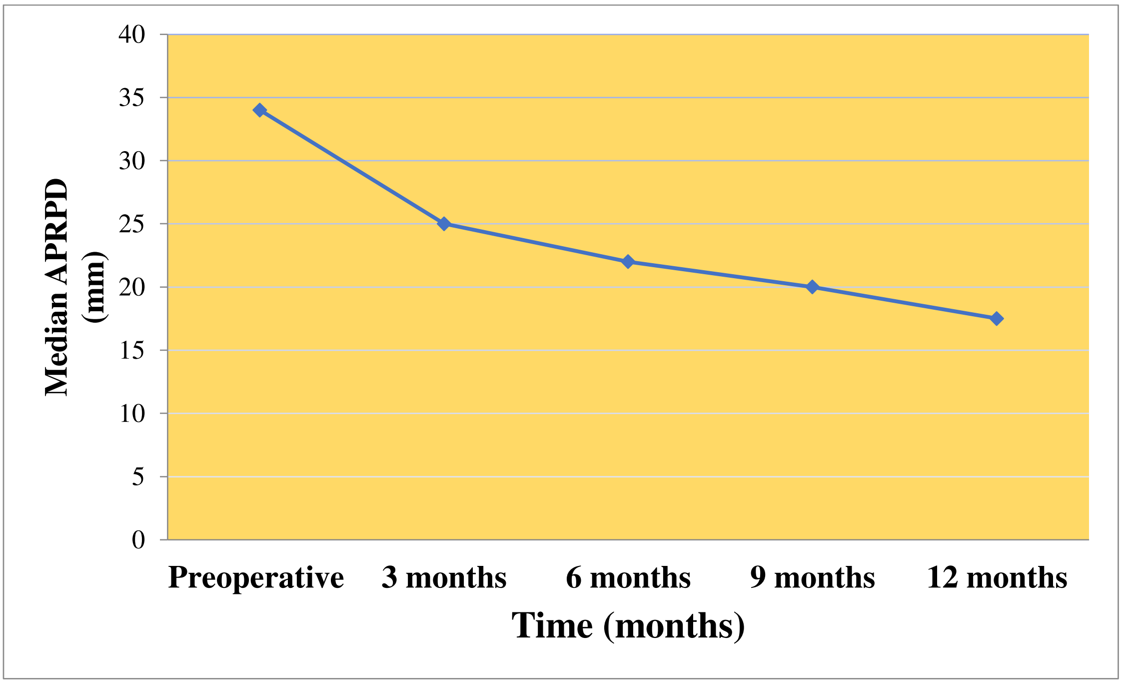

Fig. 5. Follow up of APRPD during the first postoperative year

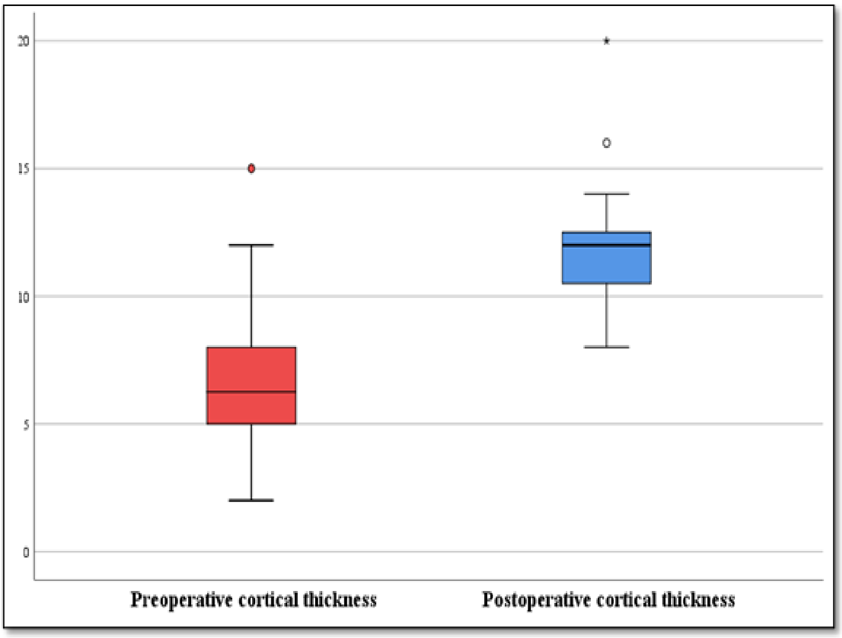

Fig. 6. Comparison between the mean cortical thickness preoperatively and one year postoperatively

The mean renal split function of the affected side on DTPA was 42.08 ± 7.93 SD (range = 15 – 49 %) preoperatively which was improved to 44.95 ± 5.9 SD. This improvement was statistically significant (p< 0.001) (**Fig. 7**). All cases showed a significant improvement in tracer clearance (decrease in radionuclide activity 20 minutes after diuretic administration). The mean tracer clearance was 26.16 ± 8.3 preoperatively and improved to 75.84 ± 9.93 postoperatively (P < 0.0001) (**Fig. 8**).

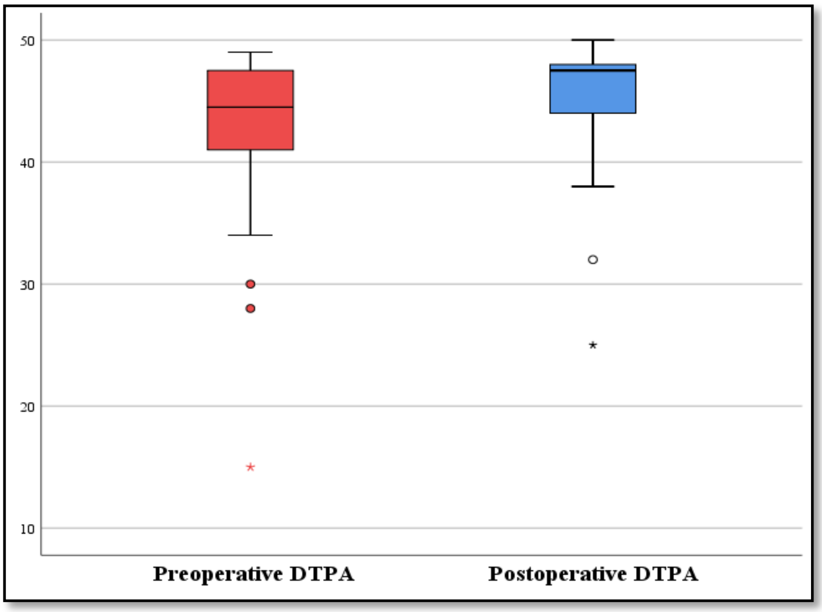

Fig. 7. Comparison between mean renal split function of the affected side on DTPA preoperatively and one year postoperatively.

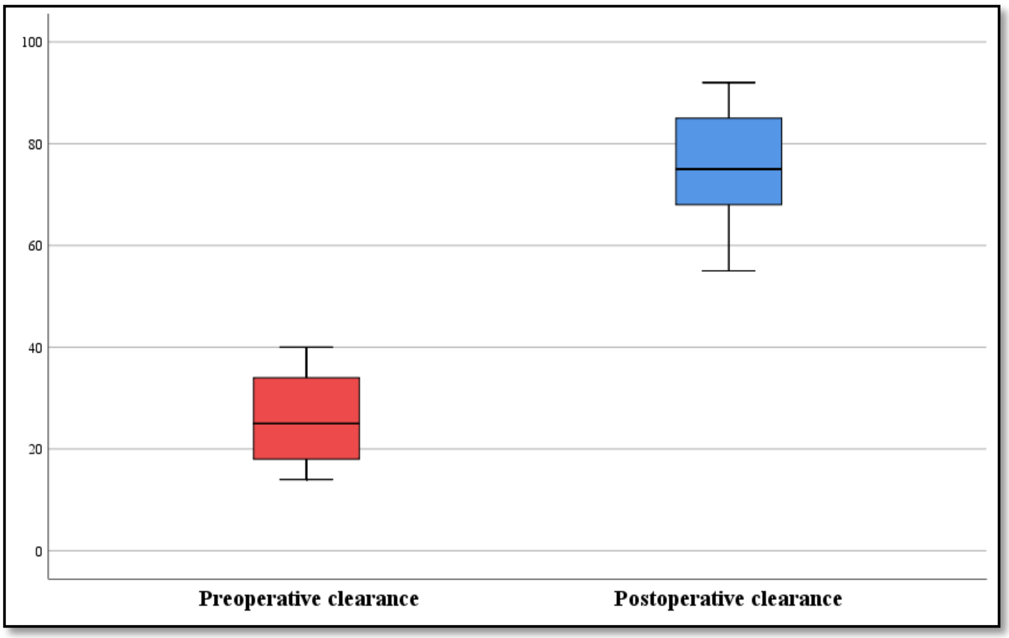

Fig. 8 Comparison between the mean tracer clearance preoperatively and one year postoperatively

Discussion

The introduction of advanced surgical tools, as well as the development of intracorporeal suturing techniques, has paved the way for reconstructive laparoscopic procedures in the pediatric population **(Metzelder et al., 2006, Schuessler et al., 1993).** Laparoscopic pyeloplasty has the advantages of excellent cosmesis, with a shorter hospital stay over the open approach. However, laparoscopy provides far more benefits than just a shorter hospital stay or less analgesic requirements. The magnification offered by laparoscopy improves surgical precision with better distinction of the narrow ureteric segment. This is especially helpful in small infants, in whom the normal ureter is quite small. In LP, the operation is performed with the UPJ in situ, without the need to rotate the kidney leading to more accurate orientation of the ureteropelvic anastomosis. In contrast, the UPJ should be delivered out of the wound in open pyeloplasty which causes excessive traction of the tissues. Also, LP allows access to the entire ureter in cases with a longer than expected stricture in contrast to the limited exposure of the open approach **(Chandrasekharam et al., 2021).**

LP may be done through either a transperitoneal or a retroperitoneal approach. The retroperitoneal approach has several advantages, including a direct access to the renal pelvis, lower risk of injury to the intra-abdominal organ, and a lower risk of intraperitoneal extravasation of urine. This approach, however, ergonomically challenging even with expert surgeons, it necessitates working on a smaller field and represents a significant challenge in cases with crossing vessels requiring ureteral transposition. There are no significant statistical differences reported in the literature between the two approaches. Surgeon preferences and experience remain the main factors in choice for the procedure **(Rivas et al., 2013).** We adopted the transperitoneal approach as it maximizes the working space and is considerably more ergonomic for intracorporeal suturing with better view of the anatomical landmarks.

In contrast to conventional "open" surgery, laparoscopic intracorporeal knotting is one of the most challenging tasks to learn. It requires not only advanced and well-honed motor skills, but also dexterity, proficiency, and special spatial cognition expertise. Prolonged knotting time, strenuous efforts to insert the needle, and achieve adequate knotting strength can cause additional mental and physical stress, as well as unsecure maneuvers, sutures, or knots **(Fingerhut and Hanna, 2017).** Based on that, in LP, some operative steps may need to be modified although the principle stills the same as in open surgery. So, since its first description by **Kavoussi and Peters (1993)**, LP is continuously evolving with various modifications to simplify the technique to make it a more feasible alternative over the open one.

The most important and critical component of pyeloplasty operation is the ureteropelvic anastomosis, which has a significant impact on the outcomes. Several techniques for ureteropelvic suturing have been described in the literature, but there is no agreement on the best technique. The prerequisites of a good technique include water-tight, dependent, tension free, and funnel–shaped anastomosis. Other important criteria include mucosa to mucosa anastomosis, excision of any redundant renal pelvis and diseased ureter, and to minimize direct ureteral handling **(Mandhani et al., 2004).**

We adopted a modified technique of dismembered pyeloplasty previously described by **Yang et al. (2015)** and reevaluated in a study by **Radfar et al. (2019).** Also, it was described by **Koga et al. (2019)** with a retroperitoneal approach. In this technique, the ureter is not dismembered completely from the renal pelvis during ureteral spatulation leaving a portion of the redundant dilated pelvis in continuity with the ureter. It is used as a handle for ureteric manipulation which allows easy spatulation and suturing. This part is excised later after completing the ureteropelvic anastomosis. The touchless ureteric manipulation helps to minimize ureteral grasping with any instrument keeping healthy edges for the anastomosis and prevent crushing damage which may lead to fibrosis and anastomotic stenosis. Also, remaining in continuity helps to prevent ureteral torsion and preserve the correct orientation of the incised renal pelvis (the flap should be oriented medially). These advantages are very important and helpful to perform properly oriented anastomosis, as the ureter usually becomes difficult to handle after it has been fully dismembered, making subsequent spatulation and orientation a real challenge **(Neulander et al., 2006).**

Current studies suggest that stenting either with internal (DJ) or external stents is important to help anastomotic healing and minimize urinary leakage. DJ stent is minimally invasive, safe, and efficient; however, removing the stent requires an additional operation. On the other hand, external stenting has the benefits of simple stent removal but also it has the disadvantage of causing more trauma **(Elmalik et al., 2008).** Retrograde stenting before the main operation is usually unnecessary and time consuming.

Also, presence of the stent makes ureteric spatulation more difficult and the drained renal pelvis will change identification of the most dependent part of the pelvis which is easier to be defined with a distended pelvis. Antegrade stenting has the advantages of avoiding one more procedure with easier spatulation than retrograde insertion **(Mandhani et al., 2004).** A multicentric study including 15 institutions found that antegrade stent insertion has lower rate of complications in comparison to the retrograde manner **(Silay et al., 2016).**

In this study, we described 3 tricks to facilitate antegrade DJ insertion and made it easy. These techniques were simple, quick, and with no extra coast using readily available instruments. The mean time required for DJ insertion was about 8 min (ranged from 3 – 15 minutes) which can be considered a short time for this step. The use of the syringe needle technique has the advantage of allowing two free working hands without additional incision.

In our series, out of 32 patients, 6 cases (18.75%) had extrinsic obstruction due to a crossing polar vessel. This finding highlights the importance of identifying presence of a crossing vessel particularly in older children as its missing at the time of pyeloplasty will result in failure of surgery. In a study with 5 cases of failed pyeloplasty, a missed crossing vessel was the cause of failure in 3 of them (60%) **(Asensio et al., 2015).**

The longer operative time in laparoscopic reconstructive urological procedures is regarded as one of its major disadvantages, but it can be considered acceptable and competitive due to the numerous other advantages when compared to open surgery. The operative time in our series ranged from 100 to 220 minutes, with a mean of 155 minutes. The mean operative time reported in the literature ranged from 107 minutes **(Leonardo et al., 2020)** up to 214 minutes **(Ravish et al., 2007)**.

Several studies found that successful pyeloplasty in children UPJ obstruction resulted in not only cessation of deteriorating renal function or its recovery after surgery, but also in preservation of the renal function through and after the completion of adolescence. Various findings of ultrasound such as downgrading of anterior–posterior pelvic diameter, cortical thickness and parenchymal to pelvic ratio were described as predictors for surgical outcomes. However, early improvement on ultrasound could also be due to renal pelvic reduction rather than real improvement **(Chertin et al., 2009).** The improvement of renal cortical thickness may be an indirect sign of postoperative success and improvement of renal function. After the obstruction was corrected, renal function could recover, especially in patients with good baseline preoperative renal function. The return of kidney function may correlate with the nephron mass, as determined by the cortical thickness (**Ulman et al., 2000).**

The ideal follow-up duration of children after pyeloplasty has been discussed in the literature aiming to identify potential risk factors in order to reduce unnecessary investigations with US scans and diuretic renogram **(Fernández-Ibieta et al., 2016). Varela et al. (2021)** suggested that resolution mostly occur within 12 months of surgery, whereas hydronephrosis that persists beyond 12 months is less likely to resolve. Since the improvement in hydronephrosis is so small between the first and second years after surgery, the benefit of follow-up beyond 12 months may be questioned, as most failures appear to occur within the first year **(Romao et al., 2012).** However, there are studies that show a longer time before failure, such as **Davis et al. (2016)** and **Jacobsson et al. (2019)** in which many patients were also asymptomatic. **Värelä et al. (2021)** recommended that children with persistent dilatation should be monitored with US after 12 months, and that if dilatation worsens, a new renogram is required. Children who have complete resolution of hydronephrosis at 12 months are unlikely to benefit from additional follow-up.

From our point of view, the ideal workup of UPJO is a combination of US and dynamic renal scan. These investigations complement but cannot replace one another. US has the advantage of being easy to perform, with no radiation, and can be useful in identifying significant increase in APRPD postoperatively as a sign of persistent or increased obstruction. However, there is a very low correlation between the grade of hydronephrosis and DRF in pre-operative investigations. The kidney with severe hydronephrosis on US in infants can, despite delayed drainage, represent preserved DRF on renal scans. The same thing goes for follow-up investigations. Also, measurement of postoperative APRPD may be less indicative if pelvic reduction was done. Moreover, the decrease in hydronephrosis is a slow process and should be expected to persist after stent removal. A study of the time course of hydronephrotic changes after pyeloplasty showed the median time for initial improvement and later time for normalization of hydronephrosis to be 8 and 41 months, respectively **(Park et al., 2013).** It is therefore not a reliable measurement of incomplete drainage after surgery. Some authors advocated to perform a renogram three months postoperatively to offer an early opportunity to correct poor drainage and save renal function if surgery has failed **(Dy GW et al., 2016).** However, the three-month follow-up can be too early to evaluate the full recovery of DRF so, we delay it till 1 year postoperatively as long as there is no increase in the degree of hydronephrosis with US.

In our study, post-operative follow up protocol included US at 3, 6, 9 and 12 months post-operatively besides a DTPA renography, 1 year after surgery. Apart from 2 cases, all other patients showed significant improvement of the degree of hydronephrosis with reduction of the APRPD and increase in the cortical thickness. Also, there was a significant improvement in renal split function and in tracer clearance. The overall success rate in our series was 92 % which is comparable to results of other large series of open and laparoscopic pyeloplasty where the rate of postoperative complications reaches up to 12.9%-15.8% **(Nerli et al., 2009).** Thus, our complication rate complies with the literature.

The proposed etiology for pyeloplasty failure is not definitive. A previous study discovered significant scarring and peripelvic fibrosis in patients who had failed initial pyeloplasty, which was attributed to urinary extravasation, urosepsis, or an overwhelming tissue reaction to the procedure **(Van Den Hoek et al., 2007).** Another study found that prolonged urinary leakage and younger patient age (less than 6 months) were risk factors for persistent obstruction **(Romao et al., 2013).** In approximately 60% of the cases, recurrence symptoms included abdominal pain and pyelonephritis. The remaining patients had progressive deterioration of hydronephrosis on follow-up examination **(Braga et al., 2007).**

The availability of resources and surgeon expertise are important factors in deciding on an intervention for recurrent UPJO. It is generally understood that managing failed pyeloplasty is technically difficult due to extensive fibrotic tissue **(Park et al., 2008).** The available options for managing recurrent UPJO with a salvageable kidney are: endopyelotomy, balloon dilatation, redo pyeloplasty and ureterocalicostomy. Endopyelotomy was widely used to treat recurrent UPJO before the laparoscopic approach became a viable option. However, the success rate of endopyelotomy for secondary UPJO can be 10-25% lower than that of open pyeloplasty, especially in the presence of poor renal function, significant hydronephrosis, and an anterior crossing vessel **(Veenboer et al., 2011).** The role of balloon dilatation is not yet clearly established. The success rate of balloon dilatation for secondary UPJO is 66%; however, this rate is based on reported series with small numbers of patients **(Doraiswamy et al., 1994).** This can be an option when there is only minor narrowing due to cross adhesions, but not when the repair has completely failed.

Several authors have traditionally regarded the open approach as the gold standard for redo pyeloplasty with reported success rates ranging from 77.8 to 100% **(Rohrmann et al., 1997).** In seven patients, Thomas et al. (2005) reported excellent results with open redo pyeloplasty for previously failed pyeloplasty, with a 100% success rate. **Braga et al. (2007)** compared endopyelotomy to open redo pyeloplasty for children with recurrent PUJO. They found that redo pyeloplasty had better outcomes than endopyelotomy with a success rate 100 vs 39% respectively. Although laparoscopic surgery is similar to open surgery, it becomes technically more difficult in cases of failed pyeloplasty. In many centers with experience in MIS, laparoscopic redo pyeloplasty is becoming a viable alternative to open redo pyeloplasty **(Cundy et al., 2013).**

In our series, 2 patients (8%) had recurrent UPJO. The first one has asymptomatic progressive hydronephrosis on sequential US after DJ removal for 3 weeks. Endoscopic dilatation was done for this patient with DJ insertion. The DJ was removed after one month and there was gradual resolution of the hydronephrosis. The other patient showed recurrent UTIs with radiological evidence of obstruction at the new UPJ. Open redo pyeloplasty was done 3 months after DJ removal.

The limitation of the present study is the small sample size and being noncomparative. However, the main strength is being prospective and that US and diuretic renography were performed and analyzed according to a standard protocol.

Conclusion

Based on our findings, we concluded that the described modifications facilitated performing the ureteropelvic anastomosis and DJ insertion rendering laparoscopic pyeloplasty to be a less demanding and much easier procedure than the conventional dismembered laparoscopic technique. These modifications significantly lowered the procedure difficulty and made it more reproducible.

List of Abbreviations

APRPD: Anteroposterior renal pelvic diameter

DJ: Double J

DRF: differential renal function

DTPA: Tc99m diethylenetriamine penta-acetic acid

LP: Laparoscopic pyeloplasty

MIS: Minimally invasive surgeries

US: Ultrasound

UPJ: Ureteropelvic junction

UPJO: Ureteropelvic junction obstruction

UTI: Urinary tract infections

VCUG: Voiding cystourethrogram

VUR: Vesicoureteric reflux

Declarations

Ethics approval and consent to participate: This research was performed in accordance with the Declaration of Helsinki, and it was approved by the ethical committee of Alexandria Faculty of Medicine with serial number 0201418. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

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