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Feasibility of Laparoscopic Pyeloplasty in Children Since Infancy

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Abstract: Background: For children with ureteropelvic junction obstruction, minimally invasive techniques offer better results for patients, but the traditional laparoscopic approach continues to be a surgical challenge, especially in infants, for which the benefit of this approach as a first-line choice is still being discussed. A retrospective analysis was performed on patients diagnosed with ureteropelvic junction obstruction (UPJO) treated by laparoscopic pyeloplasty (LP) from January 2014 to December 2019. The ages ranged from 3 months to 16 years; most patients had a primary obstruction, and only five had a previous pyeloplasty. Clinical success was defined as: the resolution of symptoms, diminished hydronephrosis on ultrasound, and improved excretion assessed through a nuclear renal scan. Throughout six years, 71 LPs were performed, of which only 57 met the inclusion criteria. The mean age was 3.5 years old. We divided the patients into two groups, group A for 1 year or less, and Group B for children 1 year and older. 16 children presented with hydronephrosis on the right kidney, and 41 on the left. 47 children presented with intrinsic obstruction, and 10 were extrinsic due to an aberrant polar artery. Prenatal hydronephrosis was detected in the majority of patients. The remaining cases presented predominantly with abdominal pain and urinary tract infection. The total mean operative time was 171 min for Group A, and 190 min for Group B. None of the children required conversion to open surgery. There was one major complication in our cohort. Our success rate of 93% was similar to that of the current literature. Our retrospective study reported shorter operative times and less complications through laparoscopic approach in infants. We attribute the shorter operative times to initiating laparoscopic intervention in young children after surpassing the initial learning curve. We recommend prospective studies in comparing both age groups in order to assert the feasibility of this procedure in all ages.

Keywords: Ureteropelvic Junction Obstruction, Pediatrics, Children, Laparoscopic Pyeloplasty

1. Introduction

Ureteropelvic junction obstruction (UPJO) is the most frequent cause of hydronephrosis (HN) in the pediatric age group. It is characterized by an obstruction at the junction between the renal pelvis and the ureter, causing a significant obstruction of urine transport. The majority are congenital and asymptomatic. Symptoms appear in children and adolescents more frequently [1, 2].

The diagnosis of HN is currently made prenatally, and the key is to identify the markers of obstruction and select those that require intervention. [3] Only 11% of prenatally diagnosed with HN corresponds to UPJO; of these, one-third to one-half will require surgery because persistent obstruction can lead to impaired renal function and symptoms such as pain and infection. [2, 4-7].

The Anderson Hynes type dismembered pyeloplasty through the traditional open retroperitoneal approach (1949) continues to be the treatment of choice for UPJO in all age groups, with success rates of up to 95% [2, 8-10]. The

advantages of open lumbotomy in young children are shorter operative time and ease of ureteropelvic anastomosis. These are compared to the benefits of laparoscopic surgery, which include shorter hospital stays and better cosmetic results [11]. The first laparoscopic pyeloplasty was performed in 1993 by Schuessler and collaborators, describing it in a transperitoneal fashion. Three to five trocars were used, with operative times being of 210-420 minutes, suturing taking the majority of the time [12]. In 1995, the first successful cases in children comparable to those obtained with the open technique were described by different surgeons and in other countries. Laparoscopic pyeloplasty is described as a challenging procedure but with evident advantages over the conventional approach even for those cases of restenosis, including shorter hospital stays and early return to normal activities [13-16].

The accurate, sufficient, and rapid dissection of the left ureteropelvic junction through the colonic mesentery is shown to be possible during the transabdominal approach, especially in variants with significant extrarenal pelvis dilation. This paper reports our experience with traditional laparoscopy for treating UPS in the last 6 years in pediatric patients.

2. Methods

We did a retrospective review with consecutive patients between 3 months to 16 years old, who underwent primary or secondary repair of UPJO by Transperitoneal Laparoscopy (TLP) from January 2014 to December 2019 (n=70). In most cases, the diagnosis was made prenatally; all were confirmed later by renal ultrasound (US) and nuclear scan (diuretic $MAG3^{Tc99}$). Indications for surgery were: asymptomatic patients with persistent high-grade hydronephrosis, a differential renal function (DRF) < 40% with a flat or ascendant excretion curve, or a decrease of DRF >10% during follow-up. Progression of HN or urinary symptoms (flank pain, urinary tract infection, or hematuria). We registered: demographic data, laterality of the obstruction, type of presentation, surgical time (taken from anesthesia notes), blood loss, days of postoperative analgesic use, days of drainage and urinary catheter, length of stays (from admittance to discharge from the hospital), and immediate complications (within seven days after the procedure). Follow-up was for a minimum of six months: workup included the US and diuretic $MAG3^{Tc99}$ renography. Patients with incomplete data or no postoperative follow-up of at least six months were excluded (n=13). Finally, we divided the patients into two groups; Group A for patients younger than 1 year and Group B for patients equal to or older than 1 year old. We had the approval of the internal ethics board of our hospital. Success was defined as: the resolution of symptoms improved HN in the US, and excretion in nuclear scan in the follow-up.

2.1. Preoperative Assessment

Most patients lived considerable distances from the medical center, prompting hospitalization the day before. Some patients underwent retrograde pyelogram to rule out additional ureteral anomalies, which would modify the surgical approach. A urinary catheter was utilized, in which 1cc of methylene blue ink was instilled through the catheter, which was then clamped. All of the children underwent dismembered pyeloplasty as traditionally described with absorbable sutures 5-0 or 6-0 of PDS®, Monocryl®, or Vicryl®. Ureteral Double - J ® stents were left inside the ureter for at least four weeks. Certificated pediatric urologists performed the procedures.

2.2. Surgical Procedure Description

The patients were placed in a lateral decubitus position with the affected side up. With the operating table at 0 degrees, we used three ports, 3 or 5mm depending on the patient's size. We infiltrated first the port sites utilizing lidocaine as a local anesthetic. The first one was for the 30-degree scope at the umbilicus, and the other two were working ports in the subcostal, and pararectal infraumbilical plane. The surgeon and first assistant situated themselves in front of the patient. (Figure 1).

Figure 1. *Lateral decubitus position, three ports placed, 3 or 5 mm depending on the patient's size.*

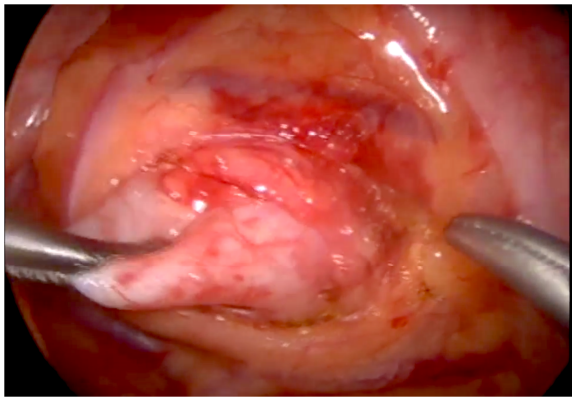

Figure 2. *Transmesenteric approach. The dilated renal pelvis protrudes behind the mesentery of the colon. We created a small window at the avascular plane, to expose the ureteropelvic junction (grasped with the Maryland).*

A transperitoneal approach was performed in all cases, with most left obstructions being repaired by a transmesocolic approach and the rest by right or left colon displacement. For the transmesenteric approach, we identified the dilated renal pelvis protruding behind the mesentery of the colon. We created a small window using monopolar electrocautery or harmonic scalpel at the avascular plane to expose the ureteropelvic junction. (Figure 2) We placed a percutaneous silk stitch in the renal pelvis for suspension, facilitating exposure for proceeding with the pyeloplasty, resecting the stenotic segment, and performing an oblique cut at the pelvis, utilizing scissors or a harmonic scalpel. If the pelvis was too redundant, we excised the extra tissue as well. (Figure 3).

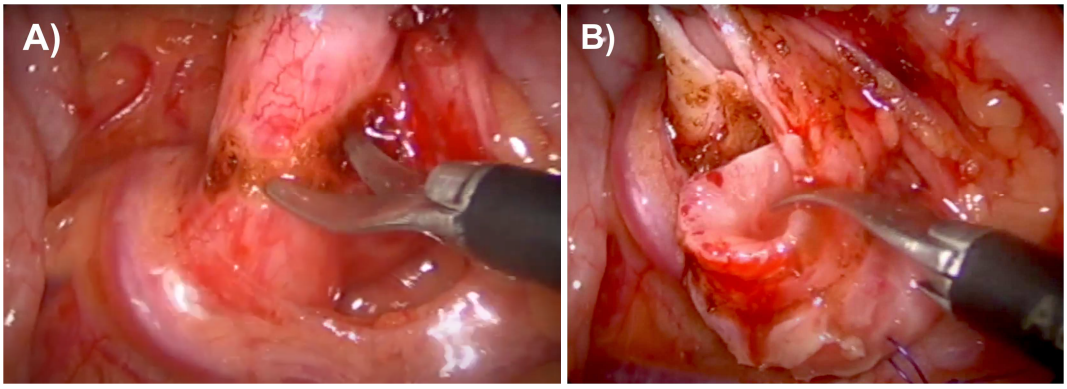

Figure 3. *A) We placed percutaneous silk or another suture stitch in the renal pelvis for suspension, facilitating exposure for proceeding with the pyeloplasty, B) performing an oblique cut at the pelvis, utilizing scissors.*

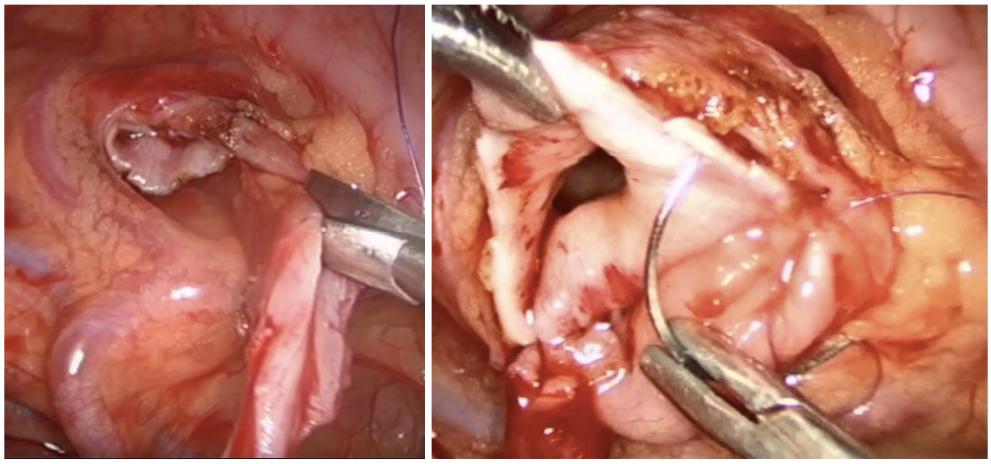

Figure 4. *Left: Spatulate with scissors 0.5 - 1 inches beside the ureter below the obstruction. Right: Interrupted stitches were used on the rear and anterior wall.*

We utilized scissors to spatulate 0.4 - 0.8 inches beside the ureter below the obstruction. PDS®, Monocryl®, or Vicryl® 5-0 was utilized. The first suture was placed at the angle of the previous cut on the lateral side of the ureter and the most sloped portion of the renal pelvis. Interrupted stitches were utilized on the rear wall and running sutures on the anterior wall. (Figure 4) Before completing the anterior wall, we used a 16G IV catheter as a sheath, and we introduced the Bentson wire guide ® and the ureteral Double J catheter ® in an antegrade percutaneous fashion. We were confident that the ureteral catheter reached the bladder when methylene blue ink drained from the proximal J stent. Penrose drains were left in all cases. Some patients had an aberrant renal artery causing the extrinsic UPJO. In these cases, an extra percutaneous suspension suture was placed on the ureter before the pyeloplasty, leaving the artery behind the anastomosis.

3. Results

We performed a total of 70 LPs, of which only 57 satisfied the inclusion criteria for the study. Ages ranged from 3 months to 16 years; there were ten patients in Group A (1-year-old or less) and 47 in Group B (> 1-year-old), the mean age was 3.5 years, and 16 children presented with hydronephrosis on the right kidney, and 41 presented with hydronephrosis on the left. There were 47 intrinsic and ten extrinsic obstructions (all in group B). The extrinsic case was due to an aberrant polar artery and one horseshoe kidney. Five patients from Group B had a previous surgical failure. Most of the patients in Group A presented with prenatal HN, and the diagnosis was confirmed at birth. The other group mostly presented abdominal pain, urinary tract infection, hematuria, enuresis, and fever. The most common symptoms

were the first two. All underwent the US and renal scintigraphy before surgery. Demographic data is in Table 1.

Table 1. *Patient Demographics.*

Number of Patients	57		
Average Age	3.5 years old		
Gender	Female	Male	
	10	47	
Side	Left	Right	
	41	16	
Abarrent crossing vessel	Yes	No	
	10	47	
Symptoms before Surgery	Prenatal Hydronephrosis: 20	Abdominal Distension: 1	Abdominal Pain: 7
	UTI 18	Nausea/Vomiting: 2	Lumbar Pain: 5
	Hematuria: 1	Incidental finding in the US: 1	Enuresis: 1
Other aberration	Kidney stone	Horseshoe kidney	
	1	1	
Previous Surgery	Yes	No	
	5	52	

In some patients ascending pyelography was performed at the beginning of the surgery (n=24) 2 in Group A and 22 in Group B, of which only one in the latest group required a change of surgical plan and also performed pyelotomy. The total mean operative time was 171.5 min for Group A and 190.5 min for Group B. Only one patient of group A required blood transfusion during the surgery due to bleeding (90ml); none required conversion to open surgery. All patients were given non-opioid analgesics during the postoperative period with an oral or intravenous schedule, and an intravenous rescue dose of opioid analgesia was indicated for severe pain. Severe pain was measured using the visual analog scale and the objective pain scale (OPS) for younger children. We gave all patients intravenous 1st generation cephalosporin beginning an hour before surgery and during their hospital stay. One child in Group B, who suffered from an intestinal perforation, required a long period of opioid use (10 days). The rest of the patients averaged only 24 hours of rescue dose usage. The length of postoperative hospital stay is registered as a minimum stay of 24 hours, with a mean of 3.4 days. We did not count if the admittance day was a day before the surgery; this happened in patients from another state. All patients were left with a Penrose drain and urethral catheter for at least 24 hours. The length of stay was extended due to most of our patients residing in another state, causing concern for adequate care in case of an event.

Among the immediate post-surgical complications, six had significant urinary leakage for more than 48 hrs due to Penrose drainage, one case underwent cystoscopy and double -J ® stent replacement, and the rest resolved conservatively. One patient from Group B had moderate abdominal pain, requiring 48 hours of rescue dose with intravenous opioid analgesic and a hospital stay of 72 hours. Only one patient (Group B) presented a febrile urinary tract infection and was discharged on the third postoperative day with oral antibiotics. Two patients (group B) presented with macroscopic hematuria and were discharged on the 5th and 6th postoperative days without affecting the long-term evolution. Four patients presented extended postoperative ileus, so they remained hospitalized until they tolerated enteral feeding. One patient had a prolonged hospital stay of 34 days, secondary to an intestinal perforation detected within the first hours after surgery (which was resolved after exploratory laparotomy and primary repair). One patient in each group presented with migration of the catheter below the ureteropelvic junction. During outpatient follow-up, only one presented evidence of restenosis by gammagraphy and increased hydronephrosis by ultrasound. In this case, the ureteral catheter was removed, and a new one was placed by cystoscopy, avoiding further surgery.

The ureteral catheter was removed by ambulatory surgery via cystoscopy, averaging four to six weeks, with no presenting complications. Follow-up was done with a minimum of six months to a maximum of sixty months, due to the second recurrence of UPJO. A control US and a nuclear scan were requested between six and twelve months postoperatively.

One of the five cases with a previous failed surgery presented with restenosis at six months requiring replasty, which was performed openly. Out of our cohort of 57 patients, there were 4 cases of restenosis. The patient in Group A resolved with the placement of a new JJ stent. Out of the three patients belonging to Group B, one required OP, and two required LP reoperation. None of them resulted in the functional exclusion of the renal unit.

Despite follow-up, three patients (all in group B) with no data of restenosis by ultrasound or renal scintigraphy evolved to renal exclusion. A nephrectomy was performed in one patient due to the persistence of febrile UTI; the other two were discharged asymptomatically.

Postoperative results and Follow up are summarized in Table 2 and Table 3.

Table 2. *Postoperative results between the first 7 days after the procedure. *TLP: transperitoneal Laparoscopy: UTI: urinary tract infection.*

Immediate results in patients operated by TLP	Group A < 1 year old (N=10)	Group B = > 1 year old (N=47)	Both Groups %
Urinary Leak	2	4	10.52
Intestinal perforation	0	1	1.75
Ureteral catheter migration	1	1	3.5
Ileus	1	3	7
hematuria	0	2	3.5
UTI	0	1	1.75
Significant Abdominal Pain	0	1	1.75
NO COMPLICATIONS	7	34	71.92

Table 3. *Follow up.*

Group of Age	Group A (N=10)	Group B (N=47)
Follow-Up Median Range	15.4 Months	
Average Surgical Time	181 minutes	
	171.5 minutes	190.5 minutes
Pielography Before Surgery	2	22
Resolution of Symptoms	7	43
Restenosis	1	3
Renal Exclusion	0	3
SFU Classification Pre Surgery		
Grade 4	7	29
Grade 3	2	16
Grade 2	1	2
Grade 1	0	0
SFU Classification Post Surgery		
Grade 4	0	2
Grade 3	1	7
Grade 2	3	24
Grade 1	4	13
No Hydronephrosis	2	0
Renogram Presurgery Ascendent curve	10	44
Renogram Postsurgery descendent or flat curve	9	41
Renogram Postsurgery ascendent curve	1	3

4. Discussion

The standard treatment for UPJO for all ages continues to be the dismembered pyeloplasty described by Anderson Hynes. The open approach (OP) continues to be the most performed in the pediatric age. Minimally invasive techniques, including traditional LP, robotic-assisted laparoscopy (RL), and endourological procedures, are most commonly practiced in high-concentration pediatric hospitals. Since the first laparoscopic dismembered pyeloplasty was successfully described in pediatric patients in 1995, controversies have been recorded. Some authors recommend not performing the procedure in children under six months of age since the difficulty of intracorporeal suturing could prolong surgical times, especially in children between 3 to 4 months. Before 2009 we used to perform LP pyeloplasty only on patients six months or older due to following the prevalent train of thought at that time [5, 13, 17, 18]. An observational study reported a 50% decrease in patients under six months of age undergoing pyeloplasty, suggesting that they should be operating at an older age. Knoedler et al. made an analysis with a sample of 4590 pediatric patients who underwent pyeloplasty by UPJO in 195 different hospitals. The laparoscopic approach was duplicated due to the experience obtained in the last years of the study and the lower morbidity offered by the minimal invasion [19]. Studies have shown equivalent effectiveness and safety between LP, OP, and RL. LP is not as popular due to the technical demands involved in knot tying. The introduction of the Da Vinci robot (Intuitive Surgical, Sunnyvale, Ca, US) has facilitated intracorporeal suturing, and only the high cost of the equipment limits its widespread use [20].

Regarding etiology and age of presentation, our results were similar to those reported in the literature. Forty-seven had intrinsic ureteropelvic stenosis (83.4%), and only ten patients had extrinsic stenosis (17.54%). The surgical indication was high-grade HN (III and IV), deterioration of renal function, deterioration of the obstruction curve, diagnosed by nuclear scan, and urinary symptoms [21]. Laparoscopic surgery has been practiced in our hospital center since 1997; the learning and skill curve has been constant. Kojima reported 95% success in the resolution of UPJO by LP in children from 18 months of age and found it easier to perform the trans mesenteric approach in cases of left UPJO; the surgical time was shorter compared to adults (236 vs. 258 min) [22]. Szavay, with a sample of 70 pediatric patients with a mean age of 20 months, operated on all by laparoscopy with a mean time of 140 min. Conversion to open surgery was performed on a 2-month-old patient for an aberrant polar vessel, a laparotomy for inadvertent intestinal perforation, and a postoperative nephrectomy for peritonitis,

with a mean stay of 7 days on his patients and a success rate of 98% [23].

Our series reports a mean operative time of 181 min, with zero conversion to open surgery, including 5 cases with a previously failed OP or LP pyeloplasty, in our previous series we reported a mean time of 255 min [17].

The standard was to use only three trocars; on some occasions, a 4th trocar was utilized to expose the renal pelvis. Garcia-Aparicio reports a time of less than 200 min in his case series after he started using a fourth working trocar, with a mean operative time of 235 min [18].

Since a preoperative pyelogram may show the surgeon the exact anatomy of the obstruction before surgery, this changed the surgical plan in only one case (pyelotomy), so this conduct could be questionable.

Our most serious complication was one inadvertent intestinal perforation repaired in the first hours after the LP. We removed the JJ ureteral catheter by cystoscopy 4 to 6 weeks after surgery. Seven studies reported post-surgical complications in a systematic review of OP vs. LP. 192 cases of LP had urinary leakage (14 cases), UTI (6 cases), stricture in two instances, and bleeding in 2 cases. [24].

On the other hand, a prospective study of 30 patients, which compared 15 OP versus 15 LP, reported a mean LP time of 163 min, which decreased as the study progressed and greater skill was acquired. There were only four complications in the laparoscopic group. Those complications perhaps occurred during the preoperative ascent of the double J stent and excluded one patient due to conversion to open surgery; there was no recurrence of stenosis in both groups with long-term follow-up similar to ours. In our opinion, installing the double J in a percutaneous antegrade manner instead of placing it through cystoscopy maintains HN. It facilitates dissection and identification of the obstruction during the procedure. When encountering difficulty in passing the double J through the ureter, practical alternatives are performing a nephrostomy or not leaving a stent, especially in smaller patients.

The feasibility of performing TLP for pyeloplasty in infants has been discussed for some time due to the technical difficulty it demands. Excellent short and long-term results have been reported in some studies. Vicentini refers in his sample a median of 45 months of age, including 23 children under 24 months, with a resolution of obstruction demonstrated by DTPA renogram and relief of symptoms in all of his patients within 20 months of follow-up [25]. Notably, ten patients in our sample were younger than 12 months. Other authors describe as an alternative the retroperitoneoscopic pyeloplasty with three ports as a safe option for small children (>6kg). However, the risk of pyelic perforation due to massive dilatation of the pelvis when introducing the trocars and the reduced spaces that make intracorporeal suturing difficult limit its practice [10].

TLP has the advantage, contrary to what one might think with OP, of having more detail at the time of LP despite the reduced space that the abdominal cavity may represent in children under two years of age. Restenosis can occur in up to 11% of patients, requiring surgical reintervention that offers better results than endoscopic treatment, and TLP is a good option for these cases, with less morbidity compared to open surgery. Al Hazmi reported in his series of cases (n=22) mean age of 22 months, the youngest being 4.5 months, a mean surgery time of 200 min in redo laparoscopic pyeloplasty, a mean hospital stay of 3 days, no surgical conversion, and obtaining a success rate of 90.9% (20 patients) [16]. Abdel-Karim reported a comparison between redo pyeloplasty: OP vs. TLP, with similar complications, less postoperative pain, with a mean hospital stay of 6 vs. four days, respectively. This means that TLP in reoperations maintains advantages over open reoperation. [26].

The average post-surgical follow-up in our series was 15.4 months (6m - 60m), using ultrasound, MAG^{Tc99} renal scintigraphy, and symptom surveillance. We had 4 restenoses, resulting in a clinical success rate of 93%.

Polok and collaborators, in their retrospective study, compared LP (n=95) vs. OP (n=131) groups, reporting success in the first group of 91.57% vs. 91.7% in open surgery. Eight patients in the LP group and 9 in the OP group required a new surgery due to recurrence of UPJO [11]. During the follow-up, there were 3 cases that, despite improving HN by the US and not presenting an obstructive pattern of excretion in the renal scintigraphy, they evolved into renal exclusion; one required nephrectomy due to recurrent UTI. Several studies report improvement of differential renal function by scintigraphy and HN after pyeloplasty, especially in small patients, since at puberty, a stage where weight and metabolic demand increase, a decrease in renal function could occur, especially in those with some degree of renal impairment [27, 28].

Castagnetti concluded that patients with moderately impaired renal function due to renography and those diagnosed postnatally by symptoms are more likely to have improved renal function after surgery. Improvement in renal function is not related to the timing of surgery, the age at the time of surgery, the degree of ultrasonographic HN, or the pattern of renogram excretion pre-surgery [3].

Although we know that the success reported by several authors is similar between the OP and conventional laparoscopic approach (95%) [24, 29], the latter continues to be described as a challenging surgery, which requires a steep learning curve for similar surgical times. This is why some centers prefer robot-assisted laparoscopic pyeloplasty. Correcting the tremor and extending the movements by rotating the robotic arm facilitates pyeloureteral anastomosis, with success rates comparable to traditional laparoscopy (99%), and fewer post-surgical complications, with disadvantages such as its high cost and the large size of the robots in a small child's abdomen [29].

Several authors use a simulation model as practice in their surgeons before performing the TLP, overcoming the difficulty, and improving the learning curve to obtain good results. The problem is that not all hospitals have a simulation center, and the low-cost simulators to practice at home do not have the supervision of a teacher [2, 30, 31].

5. Conclusion

A minimally invasive approach to correct UPJO remains a point of debate, especially in younger children. Though statistically there is insufficient data, clinically, we have observed significant postoperative results and shorter operative times through the laparoscopic approach.

Our center currently performs TLP in most patients ranging from 3 months to 18 years old. Our learning curve has improved significantly, and our current success is similar to that reported in the literature.

A prospective controlled study is undoubtedly needed to confirm the success of laparoscopic procedures in infancy. With time we believe that the conventional laparoscopic approach will become the new standard for treating ureteropelvic junction obstruction in all ages.

Conflict of Interest References

The authors declare that they have no competing interests.

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