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ORIGINAL ARTICLE

Pediatric robotic-assisted laparoscopic pyeloplasty (RALP): does weight matter?

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Abstract

Purpose RALP is rapidly becoming the new gold standard treatment for UPJO in children, who suffer from uretero-pelvic obstruction (UPJO). However, presently there is a lack of data regarding the outcomes of RALP in young infants and smaller children. This study aims to compare the outcomes of RALP in children weighing less than 10 kg and matched with an analogous cohort who underwent open pyeloplasty (OP).

Methods We prospectively compared patients who underwent RALP to a matched cohort of patients who underwent OP from our retrospectively acquired data registry. Comparative outcomes included: Demographics, success rate, complications, and length of hospital stay, postoperative pain score and failure rate. Failure was defined as the need for a secondary intervention for UPJO, or worsening hydronephrosis during follow-up.

Results A total of 15 patients with a median age of 8 months (range 5–11 months) and median weight 7 kg (range 5.6–9.8 kg) underwent RALP between 2016 and 2018, a matched cohort of 15 children who underwent OP similar in terms of age, weight, gender and affected side between 2014 and 2016. All children had prenatal diagnosis of hydronephrosis and underwent surgery utilizing combined general and regional (Caudal MO) anesthesia. Intrinsic obstruction was present in 13 of RALP group (86.7%) and in 14 in OP group (93.3%). Mean operative time was 67.8 + 13.4 min in RALP group, while 66.5 + 9.5 min in OP group. ($p = 0.76$) All but two patients in RALP group had stent inserted and required subsequent anesthesia for stent removal, while all OP children had a Salle Pyeloplasty stent inserted during the procedure and underwent removal in an ambulatory setting without the need for anesthesia. There were no failures recorded in the RALP group, while one patient in OP required a secondary intervention. Mean hospital stay was 1 day (1–2 days) for RALP and 2 days (2–3 days) for OP. There was no difference in FLACC Pain Scale in both groups. Clavien–Dindo grade I–II complications occurred in one patient from each group. Two patients from RALP underwent subsequent ureteral reimplantation due to accompanying uretero-vescical junction obstruction.

Conclusions Our data suggest that RALP can be performed safely in pediatric patients weighing less than 10 kg. with similar outcomes when compared to patients undergoing an open procedure for the same pathology.

Keywords Antenatal hydronephrpsis · Pyeloplasty · Robotic pyeloplasty

Introduction

With the widespread use of maternal ultrasound, the incidence of prenatally detected hydronephrosis has increased significantly altering the practice of urology [1, 2]. The recent review of the trends in the prenatal sonography use and subsequent urological diagnoses in United States demonstrated significant increase in the overall ultrasound use in the last two decades [2]. Moreover, the mean number of ultrasounds per pregnancy also increased significantly from 2.7 in 1998 to 4.2 in 2005 [3]. Depending on diagnostic criteria and gestation, the prevalence of prenatally

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detected hydronephrosis ranges from 0.6 to 5.4%. Ureteropelvic junction (UPJ) stenosis is the most common cause of hydronephrosis detected antenatally [2, 3]. The most commonly performed surgical procedure for the treatment of Ureteropelvic junction obstruction (UPJO) is open dismembered pyeloplasty (OP), originally described by Anderson and Hynes in 1949 with a long-term success rate exceeding 95% in the reported literature; however, since then, there has been development of various minimally invasive surgical techniques such as endopyelotomy, laparoscopy-assisted pyeloplasty (LP), and robot-assisted laparoscopic pyeloplasty (RALP) [3–5].

Although these minimally invasive techniques afford significant advantages to the patient over the open approach, few surgeons perform the advanced techniques required for UPJO treatment, limiting its use to high-volume centers [6–8].

RALP has gained attention and use because it not only offers the advantages of conventional laparoscopy concerning perioperative morbidity, but it also has a more rapid learning curve and enables increased visualization and enhanced manipulation of delicate tissues [8].

Although meta-analysis have demonstrated the efficacy and safety of minimally invasive pyeloplasty compared to OP in the pediatric population, there is a lack of data regarding the outcomes of RALP in young infants and smaller children [7–9].

In this study, we aim to compare the outcomes of RALP in children weighing less than 10 kg matched with an analogous cohort of children who underwent open pyeloplasty (OP).

Materials and methods

Institutional review board approval was obtained prior to the study.

We prospectively reviewed the record of patients who underwent RALP and compared them to a matched cohort of patients who underwent OP from our data registry. Patient demographics, radiographic imaging, intraoperative details, and surgical outcomes were obtained from a prospectively kept and continuously updated database (Table 1).

Our regimen for conservative follow-up and indications for surgical intervention in children with UPJ obstruction has been previously described [3].

In brief, ultrasound was performed on day 3 of life in patients with a prenatal diagnosis of hydronephrosis with a repeat ultrasound performed in order to grade hydronephrosis. Radionuclide studies (diuretic MAG3) were performed at age 6–8 weeks. The frequency of further examinations was tailored to findings of the initial studies. The degree of hydronephrosis was assessed according to the SFU classification. Diuretic MAG3 renal scans were done to determine differential renal perfusion during the first 2 min of perfusion in absolute units. The isotope washout curve was recorded after a bolus of 1 mg/kg furosemide was injected 15 min after radionuclide administration.

The combination of more than 5% hydronephrotic kidney functional deterioration and worsening hydronephrosis, considered SFU upgrading, served as the only indication for surgery in all reviewed study patients. Although half-time was recorded in each case as part of the well-tempered DTPA protocol, like many others we did not rely on a half-time of more than 20 min as an unequivocal sign of obstruction. All children underwent repeat evaluation, including ultrasound, 3 months after surgery. If no worsening hydronephrosis was noted, all patients underwent MAG3 renal scan 6 months postoperatively as routine follow-up after pyeloplasty. Ultrasound was performed yearly thereafter [3].

Perioperative data such as operation time, length of hospital stay, postoperative pain scale [Face, Legs, Activity, Cry, Consolability (FLACC)] scale (range of 0–10), analgesic usage, and failure rate were collected. Failure was defined as the need for a secondary intervention for UPJO or worsening hydronephrosis during follow-up.

Operative technique Laparoscopic robotic-assisted dismembered pyeloplasty was performed using the same

Table 1 Patients demographics

	OP	RALP
Age (median) months	7 (4–12)	7 (3.5–11)
Weight (median) (kg)	6.3 (4.8–10)	7 (5.6–9.8)
Renal function (%)	39.6 ± 7.3 (mean ± SD)	42.6 ± 6.4 (mean ± SD)
Lt. sided hydronephrosis (*n*)	14	15
Rt. sided hydronephrosis (*n*)	6	5
SFU grade	3.57 ± 0.56 (mean ± SD)	3.53 ± 0.67 (mean ± SD)
Intrinsic obstruction (*n*)	19 (95%)	18 (90%)
Operative time (min)	66.5 ± 9.5	57.8 ± 13.4
LOS (h)	48 (48–72)	24 (24–48)
FLACC pain sore	1	1

technique in all patients. The patients are secured in flank position and a urinary catheter is inserted. The bladder is filled with indigo carmine stained irrigation fluid.

The contralateral arm is flexed and secured to a padded arm board, while the ipsilateral arm is allowed to rest on the patient's side. The patient is then secured to the table using The Pink Pad (Xodus Medical, USA) folded blue towels and tape across the chest and hips (Fig. 1). Great care is taken to pad all pressure points and protect the child against iatrogenic injury from the robot or working arms. In all patients, three 8 mm robotic ports are placed on the midline and camera port is placed at the umbilicus. We have used an additional 5 mm port placed on the contralateral side of the operated kidney to deliver and cut the sutures during anastomosis and shorten the overall operating time. To increase the operating space, we have employed a burping technique of port placement pulling the abdominal wall with the robotic trocars up while docking the robotic arms.

Following port placement and docking of the Da Vinci Xi System (Intuitive Surgical, Inc., USA), the procedure commences by identifying the dilated renal pelvis. During dissection, the surgeon uses a bipolar microdissector forceps in the left hand and monopolar scissors in the right. For both sides, the colon is mobilized by incising the peritoneum along the white line and deflecting the colon medially. Next, the proximal ureter and renal pelvis are carefully dissected while taking care to preserve the ureteral blood supply. If an aberrant vessel is identified, it is dissected free from the UPJ/upper ureteral area. At this stage, a trans-flank holding stitch through the renal pelvis is placed to facilitate pelvic dissection and to stabilize the renal pelvis during intracorporeal anastomosis.

The ureter is dismembered proximal to the UPJ, at the level of the renal pelvis. The excess tissue of the renal pelvis is used for grasping and manipulating the ureter. The ureter is then spatulated utilizing either monopolar scissors or Pots scissors depending on the surgeon preference and the diameter of the ureter. Laparoscopic anastomosis is done in an identical way to that during open surgery. The posterior wall of the pelvic ureteral anastomosis is performed using 6/0 Maxon (Medtronic) interrupted sutures with the help of a Black Diamond Needle holder. Then, the posterior wall of the anastomosis is completed, the JJ ureteral stent is inserted in an antegrade fashion over a hydrophilic guidewire via angiographic catheter G14 that is introduced percutaneously. The presence of the indigo carmine stained urine indicates the correct position of the distal part of the stent in the urinary bladder. The anterior wall anastomosis is completed following positioning of the proximal end of JJ stent inside of renal pelvis. The use of excess renal pelvic tissue facilitates manipulation of the ureter and avoids injury to the ureteric tissue in the anastomotic area. Following anastomosis completion, the excess renal pelvic tissue is excised and the renal pelvis is closed using running 6/0 Maxon suture. No drain is left alongside the anastomosis. Leaving the camera port in place after removing the remaining ports allows the fascia of each port to be closed under direct vision, thereby minimizing the risk of damage to bowel or postoperative hernias.

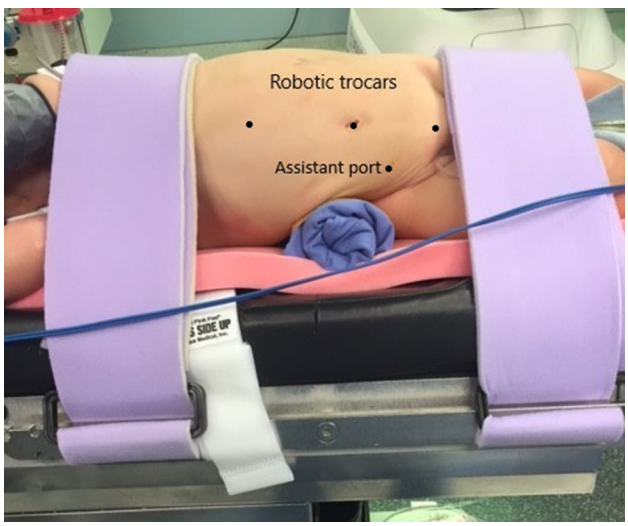

Fig. 1 Patient positioning and trocars placement

Open dismembered pyeloplasty is performed utilizing an identical technique in all patients. Salle pyeloplasty stent (Cook Medical, USA) is utilized in all patients. The stent is clamped 48–72 h after surgery and patients are discharged home. The stent is removed in the clinic 4–6 weeks following surgery.

Commercially available software Graph Pad Prism 6.01 (Graph Pad prism, Prism 6 for Windows, version 6) utilizing Fisher exact and unpaired *t* test were used for statistical evaluation with *p* value of less than 0.05 considered as significant.

Results

A total of 15 patients with a median age of 8 months (range 5–11 months) and median weight 7 kg (range 5.6–9.8 kg) underwent RALP, a matched cohort of 15 children who underwent OP similar in terms of age, weight, gender and affected side.

All children had a prenatal diagnosis of hydronephrosis and underwent surgery utilizing combined general and regional (Caudal MO) anesthesia with similar postoperative pain management as described previously [10].

Intrinsic obstruction was present in 13 of RALP group (86.7%) and in 14 in OP group (93.3%). The mean operative time including docking and console time was 67.8 + 13.4 min in RALP group, while 66.5 + 9.5 min in OP

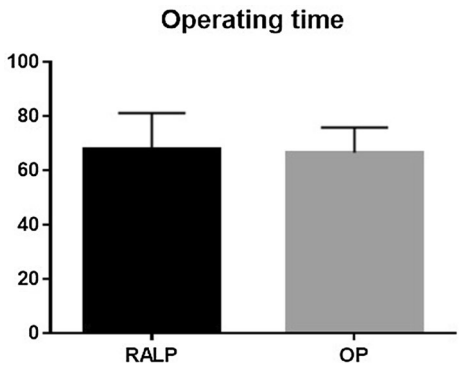

Fig. 2 Operative time in two groups

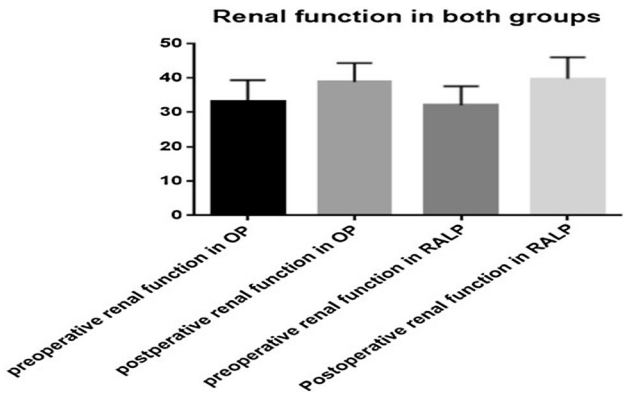

Fig. 3 Renal function in both groups

group ($p = 0.76$) (Fig. 2). Patients from both groups demonstrated significant increase in the renal function on the post-operative radionuclide studies (Fig. 3). All but two patients in RALP group had a stent inserted and required subsequent anesthesia for stent removal, while all OP children had a Salle Pyeloplasty stent inserted during the procedure and underwent removal in an ambulatory setting without the need for anesthesia. There were no failures recorded in the RALP group while one patient in OP required a secondary intervention due to recurrent UPJ obstruction Median hospital stay was 24 h (24–48 h.) for RALP and 48 h (48–72 h) for OP. All reviewed children completed at least 6 months of the follow-up. There was no difference in FLACC Pain Scale in both groups.

Clavien–Dindo grade I–II complications occurred in one patient from each group (post-operative paralytic ileus). Two patients from RALP underwent subsequent ureteral reimplantation due to ipsilateral ureterovesical junction (UVJ) obstruction. One have had surgery at the time of RALP and in the second patients JJ stent was left indwelling at the time of RALP and he underwent ureteral reimplantation 6 months later.

Discussion

The end goals of a successful pyeloplasty should result in improved renal function and hydronephrosis on ultrasound, improved drainage on diuretic nuclear renograms, and long-term esthetical satisfaction.

Minnillo et al. in a large single institution study assessed 155 pediatric patients undergoing RALP and found a success rate of 96%, with only 3% of patients requiring reoperation for recurrent obstruction [11]. Dangle et al. reported that the success rate of RALP was comparable to OP, even in infants [12].

It has been reported that the standard treatment for UPJ obstruction in children from 3 years of age is the laparoscopic approach. Some institutions reported that that approach could be utilized even in younger (4 months of age) children [13, 14]. However, pediatric laparoscopic surgery has not been extensively adopted, probably due to technical difficulty and steeper learning curves, while RALP is the most commonly reported robotic surgery in children [15].

It has also been previously demonstrated to have advantages with regard to length of hospitalization and post-operative pain and operative times comparable to open pyeloplasty which were also found comparable [16].

As for the infant population, size and weight are always to be taken into consideration. One large multicenter retrospective review report on RALP in infants is a multicenter retrospective review of 60 infants with a mean age of 7.3 months who were all treated with RALP, improved or resolved hydronephrosis was observed in 91% of these children, with two patients (3.3%) developing recurrent obstruction requiring reoperation [17].

Our data supported these findings. None of the patients from the RALP group required conversion to open surgery and all demonstrated improvement in hydronephrosis and drainage. Moreover, the robotic magnification allows precise and minimal dissection at the UPJ; therefore, we have felt safe to proceed with pyeloplasty and reimplantation at the same setting in one patent without fear of devascularisation of the ureter and spare this patient an additional anesthesia. The XI model allows to keep all principles of the open technique with meticulous manipulation on the ureter without jeopardizing its vascularization and utilizing 6/0 sutures for anastomosis similar to the open surgery.

The operating time including docking was a matter of concern over the time. Some opponents of robotic utilization in the pediatric population argued that robotic use is significantly increase an operating time and add no benefits compare with the open technique. In the presented series, the overall operating time in RALP group was similar to that of the open surgery and although we have not

presented here the docking time separately, Da Vinci XI platform allows to dock a robot in a very short period of time and eventually ruling out long standing believe that operating time increasing while using a robotic technique.

We found intrinsic obstruction as the most common pathology in both groups. In contrast, Lucas et al. found crossing vessels in 46.5% of patients who underwent RALP and showed that this resulted in a higher subjective failure rate (5.5% vs. 2.2%) and a higher rate of secondary procedures, which we did not find in our patient population [18].

In many of our patients in the RALP group, a ureteral stent was placed, and although ureteral stents are thought to be benign, studies have shown that they can carry significant morbidity [19, 20]. Furthermore, pediatric patients typically undergo an additional general anesthetic for internal ureteral stent removal, which has been a criticism by advocates of open surgery.

Reports for both open and RALP have demonstrated effectiveness and safety with the avoidance of ureteral stent placement.

The need for postoperative drainage after pyeloplasty has been a subject of debate since the introduction of the procedure in 1949 [3].

In a small series, Silva et al. reported on 27 pediatric patients undergoing RALP without any post-procedural drainage with a success rate of 100% with no complications [21].

Rodriguez et al. reported a series of 12 patients who underwent stentless RALP. There were no immediate complications, and at 6 months success rates were 100%, with either resolution of hydronephrosis and symptoms or normalization of *T*1/2 value on diuretic radio-nucleotide testing. The downside was that all patients had peri-anastomotic drainage for a mean of 1.9 days. Additionally, patients were hospitalized for a mean of 2.5 days [22].

On the other hand, advantages of stenting have been shown, such as to protect the healing anastomosis from exposure to urine and to align suture lines. Additionally, stents have been shown to reduce the risk of specific complications like urine leak and urinoma [23, 24].

In a comparative analysis of externalized uretero-pyelostomy (EUP) versus double-j internal stents, Lee et al. found no statistically significant differences in operative time, length of stay, and overall complication rate between groups, concluding that EUP stents may be a safe alternative to JJ stents after performing RALP [25].

Additional benefits of minimally invasive surgery unique to the pediatric population are cosmetic outcomes and impact on the parents or caregivers if the surgical results were equal.

Parental satisfaction rates on a validated questionnaire were higher following RALP compared to OP with respect to the size of incision scar, the burden of postoperative follow-up, and "overall life" [8].

Barbosa et al. showed that with regard to cosmetic outcomes, for pyeloplasty the scar size was important or very important to 83% of parents and that the majority would prefer RALP surgical scars over the open scar resulting from a flank incision [26].

As for complications, Gundeti et al. in a meta-analysis found that cumulative complication rate for RALP was 8.3% compared to 4.8% in OP and there was also no difference in the grade of complications between groups [27].

Although our study found RALP to be a safe procedure in pediatric patients weighing less than 10 kg, it has some limitations which should be mentioned. It does have the disadvantages of having a small patient population, and relatively short follow-up time although all our patients have completed required follow-up after pyeloplasty including anatomical and functional study which demonstrated improvement in hydronephrosis, renal function and drainage. We do agree with some researches that the majority of patients who showed improvement in hydronephrosis on postoperative US do no need radionuclide study after surgery. However, that was a pilot group of the patients in whom we have utilized a technique that was new to us; therefore, we felt that postoperative routine radionuclide studies will assist us to evaluate our surgical outcome before we will apply this technique routinely in our practice.

It should be mentioned that other reported series have had similar populations and had multicenter design. All operations in this series were performed by the same surgeon in same setting. All robotic patients were followed prospectively and none of the patients were lost during the follow-up.

Conclusions

Our data suggest that RALP proved to be a safe and successful method in patients weighing less than 10 kg, with comparable results when compared to OP.

More studies are needed to evaluate RALP, especially in the pediatric population with regard to long-term clinical outcomes, surgical costs, and patient satisfaction.

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Compliance with ethical standards

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent regarding the surgical procedure was obtained from the parents of all individual participants included in the study.

Conflict of interest The authors have no conflict of the interest with the discussion in the paper and we have nothing to disclose concerning this manuscript.

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