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ORIGINAL ARTICLE

Robotic versus conventional laparoscopic pyeloplasty in children less than 20 kg by weight: single-center experience

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Abstract
Purpose To compare outcomes of robotic versus conventional laparoscopic pyeloplasty in children less than 20 kg by weight.
Methods Nineteen patients undergoing RP and twenty-five LP under 20 kg by weight were compared retrospectively with respect to demographics and operative, postoperative, and follow-up data. For all cases, a lateral transperitoneal approach was used and all anastomoses were stented. Success was defined as the resolution of preoperative symptoms and hydronephrosis postoperatively. If either case is not fulfilled, a renogram was obtained postoperatively. Student's *t* test was used for statistical analysis.
Results Forty-four patients underwent forty-seven pyeloplasties (19 RP and 25 LP), with three patients undergoing bilateral simultaneous laparoscopic procedure with mean age of 2.7 and 2.4 years in RP and LP, respectively. The robotic procedures were superior in terms of shorter mean hospital stay by one and half day on an average. Minimum time taken for RP was 60 min, while for LP it was 90 min. Both procedures were comparable in terms of complication rate, success rate as well as operating time.
Conclusions This comparative study confirms the feasibility, efficacy, and safety of robotic pyeloplasty in infants and toddlers. The obvious advantage is being shorter hospital stay. Further prospective studies will be needed to show its superiority over LP.

Keywords Laparoscopic pyeloplasty · Robotic pyeloplasty · Pelvic ureteric junction obstruction

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Introduction

Pelvic ureteric junction obstruction (PUJO) can be acquired or congenital and can be bilateral in 10–20 % cases [1]. Management of PUJO has undergone a paradigm shift from open to the minimally invasive surgery (MIS). MIS offers advantage of quick convalescence as compared to open pyeloplasty [2]. Laparoscopic pyeloplasty (LP) requires advanced intracorporeal operative skills and correspondingly long period of learning curve, and so it still remains a demanding procedure.

The robotic platform offers advantages such as 7° of freedom, improved dexterity and precision, three-dimensional high-definition vision, and filtration of tremors [3]. The literature is scant as regards robot-assisted management of PUJO particularly in children less than 20 kg by weight; thus, we compare the technique and outcome of robot-assisted laparoscopic pyeloplasty (RP) with LP in children less than 20 kg by weight.

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Subjects and methods

All patients less than 20 kg by weight undergoing RP and LP from June 2008 to June 2015 were compared. The parameters compared were demographics and operative, postoperative, and follow-up data. For all cases, transperitoneal approach was employed. All anastomoses were stented. Total operative time was defined as time taken from start of abdominal insufflation to placement of last skin suture. In both RP and LP, we measured total operative time. All patients were followed up with ultrasound and renal function test at 1 and 6 months postoperatively. Success was defined as the resolution of preoperative symptoms and hydronephrosis postoperatively. Diuretic renogram was done if the patient was symptomatic and/or had increasing hydronephrosis.

Technique

Positioning

Robot-assisted laparoscopic pyeloplasty (RP)

Prior to positioning, the eyes were medicated and strapped with tapes (Fig. 1). The patient was brought to the edge of the table and secured with the help of straps. Alternatively, a bean bag helps in positioning the patient in appropriate manner. The pressure points that need to be padded were the shoulders, axilla, knee, and ankle. The padding was done with soft foam pads or cotton. The patient limb was covered with cotton roller pad and air warmer (Bair Hugger, associated health systems Inc.), and this helped to prevent hypothermia. Intravenous fluids were given according to Holliday and Segar's equation [4]. The intraabdominal pressure (IAP) was kept between 8–10 mmHg for infants and 10–12 mmHg for children between 1 and 5 years of age. All procedures were performed with the da Vinci Si robotic platform (Intuitive surgical Inc., Sunnyvale CA). For RP, we position the patient in a semisupine position in contrast to 45° oblique position as in standard laparoscopy (LP) (Fig. 1a). An umbilical skin crease incision was given so that the incision is hidden in the umbilical skin fold (Fig. 1b). The incision was deepened to enter the peritoneum. Thereafter, anchoring fascial stitches also known as "box stich" (Fig. 1c) were taken with a RB1 needle on a Vicryl (Ethicon Inc.). The first port was inserted which is either a 11-mm robotic port if an adult camera was to be used or a 5-mm robotic port if a 5-mm robotic camera was to be used (Fig. 1c). Once the initial inspection of the peritoneal cavity was done, the patient was turned so that the PUJO was brought in vision. Thereafter, the remaining two 5 mm ports were inserted under vision. Depending upon the discretion of the operating surgeon in some cases, a 5-mm fourth port (assistant port) is also placed, (Fig. 1d) for passing of suture material and/or for suction.

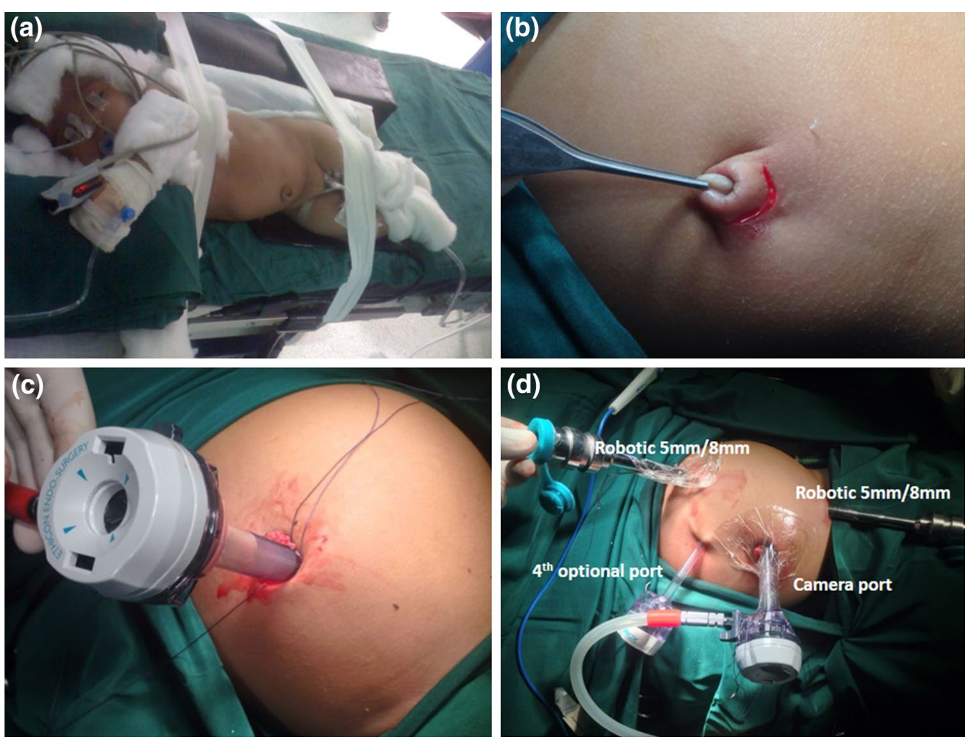

Fig. 1 **a** Patient positioning, **b–c** port placement, **d** final position of ports during RP

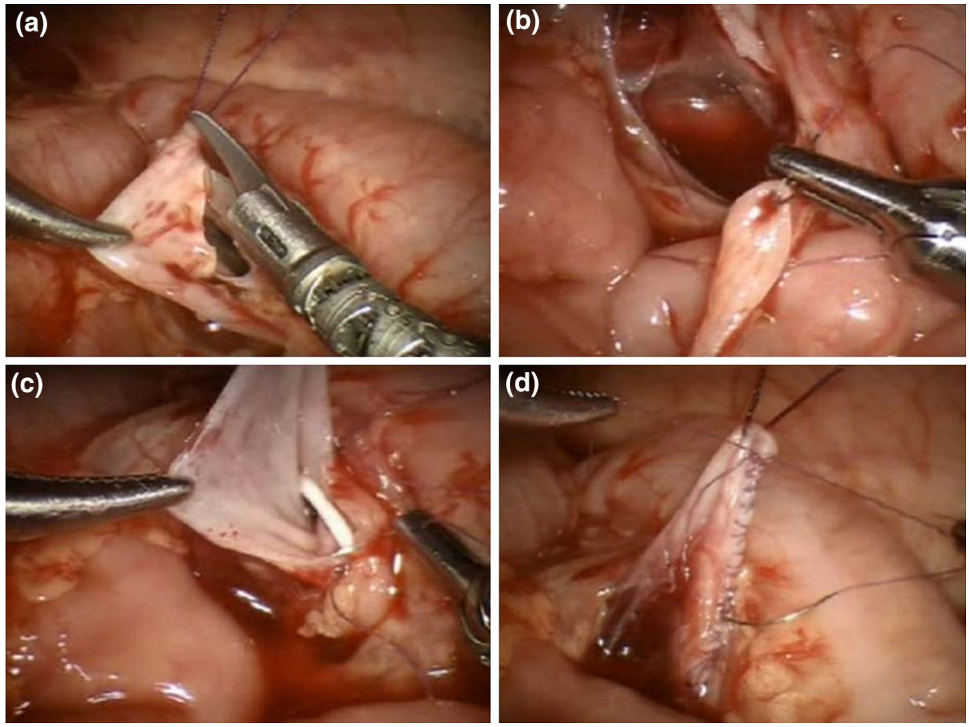

Fig. 2 Steps of pyeloplasty, **a** hitch stich being taken and pelvis opened, **b** angle stitch taken over ureteric side, **c** antegrade DJS placed, **d** completion of anastomosis

Laparoscopic pyeloplasty

The positioning mirrors that of robotic pyeloplasty except that the patient was placed in a 90° position rather than a 45° oblique position. The ports were placed so as to achieve triangulation of instruments at the UPJO. The instruments used were three 5 mm trocars with pediatric laparoscopic instruments (needle holder, grasper, and scissors). In smaller children, a Microfrance® microscissors (Medtronic) was used.

Choice of stenting

In older children, preoperative placement of pigtail catheter was done, which was converted into a double-J stent after the completion of the procedure [5]. In infants, either a preoperative placement of antegrade ureteric catheter [6] or an intraoperative placement of double-J stent was done, thus avoiding urethral manipulation for placing stent.

Technicalities of pyeloplasty

The renal pelvis and the ureter were adequately dissected to ensure a tension-free, dependent anastomosis. The renal pelvis in RP and LP was brought in optimal position by a hitch stitch which was passed percutaneously and passed through the anterior pelvis; this helped us to align the pelvis in proper position. A hitch stitch in effect also helped in reducing the need to insert an additional port for retraction (Fig. 2a).

In LP, the posterior layer was sutured first followed by the anterior. If antegrade stenting was contemplated, this was done taking the first stitch of the anterior layer. The left-hand laparoscopic instrument was used for spatulation of the left ureter, while the right-handed instrument was used for right-sided ureter.

In RP, the instruments used were robotic hook (Monopolar), robotic scissors (non-energized), and robotic needle holder (Fig. 2b, c). The 6° of freedom allowed spatulation of ureter with ease. Console surgeon setting for movement was set at "ultrafine," which helps in graded movement of the arms. The role of the bedside surgeon was critical as he is responsible for introduction of laparoscopic instruments and bedside maneuvers such as introduction and removal of needles and hitch stitches. The surgeon needs to be aware of the needle size compatibility with port size. Typically, a RB1 needle passes through an 8- and 5-mm port. The surgeon should avoid grasping the suture during the pass. The position of the virtual center on the robotic trocar (Fig. 2d) was critical in infants, far too in or out a virtual center would lead to crowding of instruments in the abdomen and make the case more challenging (Fig. 3).

Results

In the study period, nineteen patients underwent nineteen RP with mean age of 2.7 years (3 months–5 years) and mean weight of 12.5 kg (5–19 kg), while twenty-five

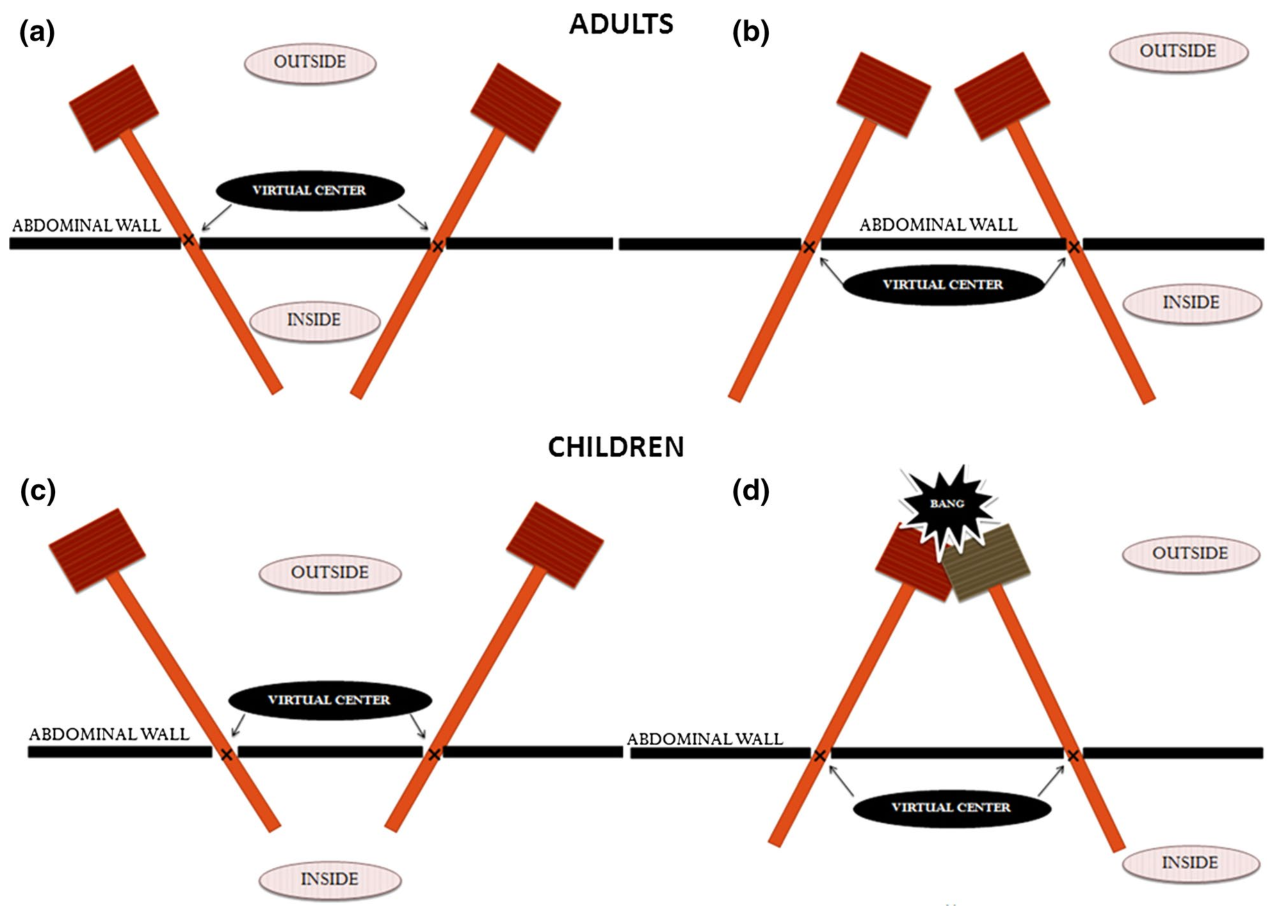

Fig. 3 Concept of virtual center; **a**, **b** in adults, as the virtual center is at shaft midway, so extracorporeal clashing of instruments is avoided. **c**, **d** In children, as the virtual center is at junction of distal 1/4th and proximal 3/4th of shaft, leads to more chances of clashing in-between instruments extracorporeally

patients underwent twenty-five (three being simultaneous bilateral procedures) LP with mean age of 2.4 years (5 months–5 years) and mean weight of 10.85 kg (5.5–16 kg). There was no significant difference between two groups with respect to baseline parameters (Table 1). The mean drop in hemoglobin level in RP was 0.55 ± 0.55 and 0.75 ± 0.48 gm/dL in LP group. The mean operating time for RP was 155 ± 46.59 min while for LP was 167.4 ± 49.7 min, p value >0.05. If we exclude robotic docking and undocking time from the total operative time (done in order to compare the technical steps of the pyeloplasty), then the mean procedure time was 144 ± 45 min in RP group which is still statistically insignificant as compared to mean operative time in LP group. In total, 25 % ($n = 3$) of the procedures were completed in less than 90 min in RP group, while only one case in the LP group was completed in less than 90 min. The robotic procedures were superior in terms of shorter postoperative hospital stay of 3.52 ± 1.50 days, p value <0.05. Only one robotic procedure necessitated conversion to laparoscopic procedure due to error 90 on the patient cart of the robot. However, there was no need for open conversion and no intraoperative complication in either group. One patient each in robotic and laparoscopy groups on follow-up underwent nephrectomy due to recurrent UTI and persistent hydronephrosis with overall success rate of >90 % in both the groups. Mean follow-up period in LP and RP was 24.8 ± 7.4 and 18.3 ± 8.2 months, respectively.

Discussion

Symptomatic hydronephrosis, declining renal function on follow-up renogram, deteriorating renal parenchyma thickness or increasing hydronephrosis on serial ultrasound, bilateral congenital PUJO or PUJO in solitary kidney, forms an indication for pyeloplasty [7].

Pyeloplasty can be done by open, laparoscopic as well as robotic technique. Open pyeloplasty is still considered to be the gold standard in all age groups as it can be done

Table 1 Showing demographic and perioperative outcomes of patients undergoing RP and LP

Parameter	RP	LP
Total no of cases	19	25
Total no of procedures	19	28
Mean age in years	2.7 (3 months–5 years)	2.4 (5 months–5 years)
Mean weight in kilograms	12.5 kg (5–19 kg)	10.85 kg (5.5–16 kg).
Male/female	15:4	21:4
Left/right	13:6	17:11 (3 B/L)
Previous surgery	1 (open pyeloplasty)	1 (open pyeloplasty)
Mean operative time (min)	155 ± 46.59	167.4 ± 49.7
Hemoglobin drop (gm/dL)	0.55 ± 0.55	0.75 ± 0.48
Drain duration (days)	2.66 ± 2.39 (only in 9 cases)	3.2 ± 1.04
Postoperative hospital stay (days)	3.52 ± 1.50	5.04 ± 1.56
Crossing vessel	5	9
Type of pelvis	All extra renal	All extra renal
Conversion rate	One (error 90)	Nil
Success rate	>90 %	>90 %
Mean follow-up (months)	18.3 ± 8.2	24.8 ± 7.4

through a small retroperitoneal incision with recent data analysis suggesting insignificant difference in postoperative analgesic requirement between open and MIS group [8]. On contrary, MIS requires more expertise and comparatively long learning curve (laparoscopy has even longer learning curve than robotic) [9].

Robotic assistance helps to expedite the suturing and reconstruction in procedures requiring suturing, and it is not clear from the present literature as to how this advantage can be translated into faster recovery and better results [10]. There are published series in the past describing the outcome of LP versus RP in adults, but there is paucity in the literature describing the outcome in small children. The operating times' perioperative outcomes and results were comparable in these series [10, 11]. Toddlers and infants (children less than 20 kg of weight) presented with unique set of challenges in our center experience which include small intraabdominal working space, smaller instruments, and suture material which potentially challenges movement of instruments and suturing.

In this context, it is felt that the advancement of pediatric robotic urologic procedures has not kept pace with advances in other subspecialties; one of the reasons could be underdeveloped instruments. In our series, we used both the 5-mm robotic instruments and the 8-mm instruments. We note that the hinge of the 5-mm robotic instruments used for pediatric cases are positioned farther toward the shaft (Fig. 2d), as compared to 8 mm robotic instruments (generally used in adults); hence, the amount of space available intraabdominally in these small patients is potentially compromised. In addition, the 5-mm robotic instruments do not have all degrees of freedom as seen in 8 mm robotic instruments. The instruments we used for dissection and suturing were Maryland forceps in the non-dominant hand and robotic hook in the dominant hand. The 8-mm port has a choice and versatility of a number of instruments to be used.

The ports tend to slip out easily in these small patients because of smaller working space makes. In all the cases, fascial anchoring sutures were taken prior to initiation of the procedure during the step of port insertion. The ports in our series were fixed with Tegaderm adhesive (Fig. 4). The Tegaderm dressing helped in retaining the port in position without the risk of extrusion during the procedure. The virtual center on the robotic trocars was attempted to be kept on the abdominal wall. The figure depicts the reason for increased clashing in children.

On comparing the LP and RP, the operative time and hospital stay were shorter in RP though it reaches statistical significance only with respect to hospital stay. The results of this comparative study suggest that this subgroup of patients benefits from a shorter convalescence with equivalent results as in LP. The robotic platform helps in suturing with smaller and fewer instruments with improved dexterity and precision which will require a skilled laparoscopic surgeon if the procedure is to be done laparoscopically. So, as the operating surgeon is more confident about the quality of anastomosis, prolonged drain placement or even drain placement can be avoided in subsets of patients undergoing RP. This is what happened in our study and is one of the factors leading to significant shorter hospital stay in RP group. The majority of laparoscopic procedures required over 2 h for successful completion of the procedure, while one-fourth of the robotic cases required less than 90 min for completion. The functional assessment as done on ultrasound shows equivalent

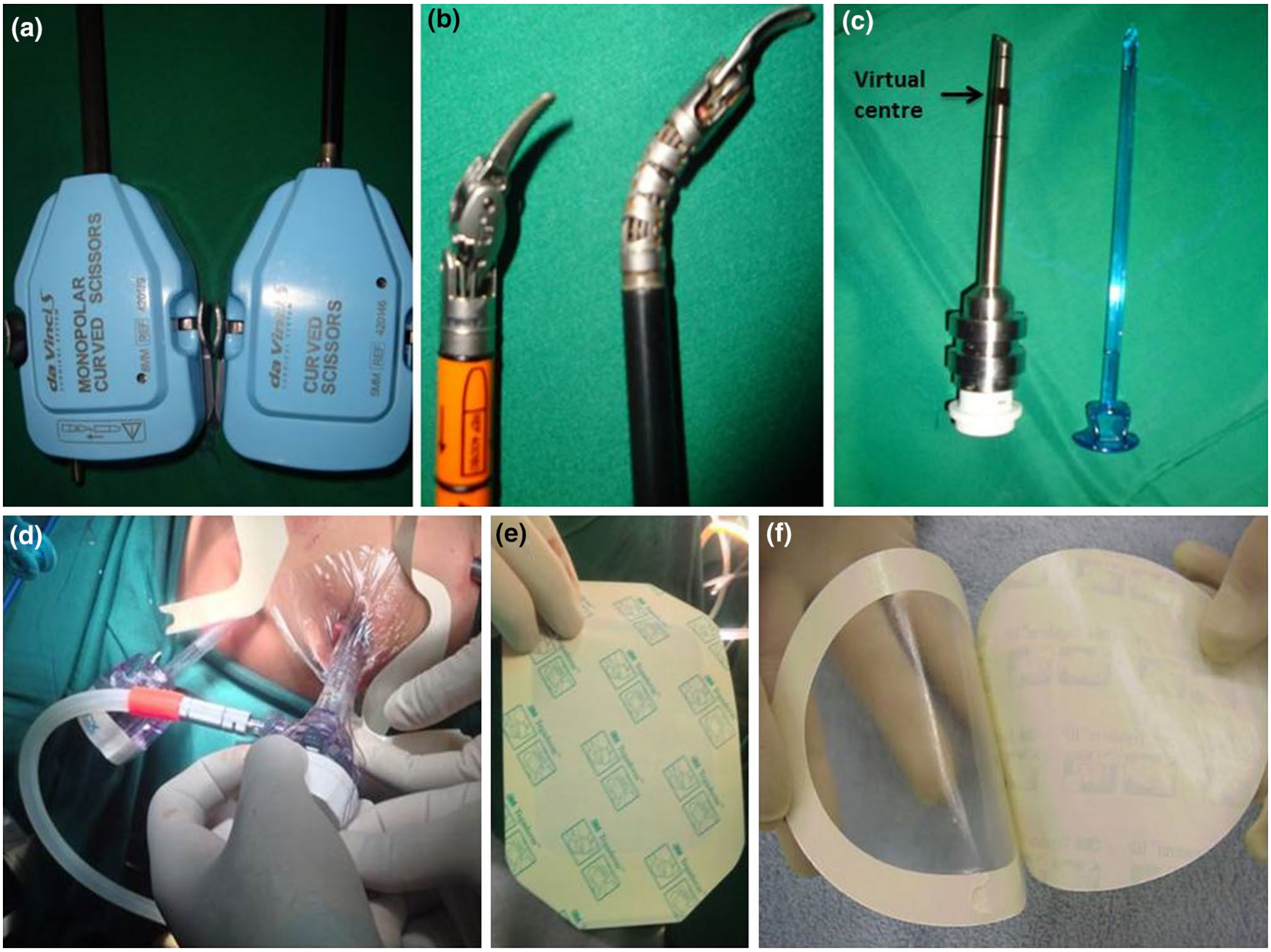

Fig. 4 **a** Pediatric robotic instruments (monopolar scissors do not have attachment for electrosurgical unit cord), **b** design paradoxically allows more intracorporeal room for the 5-mm instruments than the 8 mm, **c** depicting site of virtual center in pediatric trocars, **d**–**f** Tegaderm dressing

results. All the results correlate well with study done by Kim et al. [12]. However, Riachy et al. [13] in 2013 demonstrated superiority of RP over LP in terms of shorter operating time with equivalent results.

In a study by Chen et al., they had 3.5 % of instrument malfunction in 400 robotic cases. Among these instrument malfunction, 1.25 % (five) occurred prior to initiating the procedure [14]. In one of our RP group cases, the robotic platform had an error 99 and we could not complete the case robotically, instead completed the case laparoscopically; this case highlights the fact that a robotic surgeon should be a good laparoscopic surgeon as the principles and practice remain the same. It also made us implement the protocol that the robot should be switched and booted prior to positioning the patient (as the positioning subtly differs in LP and RP).

The obvious drawbacks of this study are a non-randomized comparison, small number, non-standardization of technique of stenting, and lack of long-term data as regards outcome. This could be overcome by future randomized comparison in these subsets of patients.

Conclusion

The results suggest that RP is feasible and safe and offered faster convalesce and equivalent results as LP for management of PUJO even in patients below 20 kg of weight. The technical modifications employed in this series include use of 8 mm robotic instruments even for toddlers, use of box stitch for fascial closure of trocar site, and use of Tegaderm for anchoring the ports and transabdominal hitch stitch for alignment of the pelvis.

Authors' contribution Ganpule A involved in project development, data analysis, and proof reading and wrote the manuscript. Jairath A wrote the manuscript and involved in data collection and analysis. Singh A edited the manuscript and involved in proof reading. Mishra S edited the manuscript and involved in proof reading. Sabnis RB edited the manuscript and involved in proof reading. Desai MR edited the manuscript and involved in proof reading.

Compliance with ethical standards

Conflict of interest None.

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