Original Article

The learning curve for robotic-assisted pyeloplasty in children: Our initial experience from a single center

Noor Nabi Junejo[1,2], Anwar Alotaibi[3], Saeed Malwi Alshahrani[4], Ahmad Alshammari[2,5], Craig A. Peters[6], Hamdan Alhazmi[7], Santiago A. Vallasciani[8]

[1]Urology Department, King Faisal Specialist Hospital and Research Centre and College of Medicine, Alfaisal University, [2]Pediatric Urology Division, Urology Department, King Faisal Specialist Hospital and Research Centre, [3]Biostatistics, Epidemiology and Scientific Computing Department, King Faisal Specialist Hospital and Research Centre, [4]King Faisal Medical City for Southern Region, Abha, [5]Pediatric Urology Division, Department of Surgery, King Abdullah Specialized Children Hospital, National Guard Health Affair, Riyadh, Saudi Arabia, [6]Children's Medical Centre, University of South-Eastern, Dallas, Texas, USA, [7]Urology Division, Department of Surgery, King Saud University Medical City and College of Medicine, King Saud University, Riyadh, Saudi Arabia, [8]Pediatric Urology Division, Surgery Department, Sidra Medical and Research Center, Doha, Qatar

Abstract

Background: Robotic-assisted pyeloplasty surgery has become the preferred approach of ureteropelvic junction obstruction (UPJO) in pediatrics. However, to our knowledge, there is limited data on the learning curve for robotic-assisted pyeloplasty in children and no similar study from Saudi Arabia.

Aims: The objective of the study was to evaluate the progression of the surgical team performing robotic-assisted laparoscopic pyeloplasty (RALP) and to assess the feasibility of the RALP in children, since it is having been recently started in the Kingdom.

Settings and Design: Retrospective charts and surgical videos review at the tertiary care centre.

Subjects and Methods: After approval from the internal review board (IRB), we reviewed the surgical video recording of the RALP procedure of 15 patients presented with UPJO from January 2016 to October 2017. Statistical analysis was done for the variables includes dissection time, pyelotomy, anastomosis on both sides, and total surgery time and calculated in minutes. Renal ultrasound reviewed to assess any change in grade.

Results: Fifteen patients with UPJO underwent RALP. Of 15 cases, nine were primary and six cases as secondary UPJO. The median age was 8 (3–15) years. Out of 15 cases, 13 and 2 patients diagnosed as Society for Fetal Urology grades of 4 and 3, respectively. Total operative time was prolonged in secondary group as compared to primary pyeloplasty group (mean [standard deviation (SD)]: 166.3 [35.1], range: 125–223, $P = 0.0028$ versus mean (SD): 149.17 (30.4), range: (114–207), $P = 0.0008$). The success rate was 100% in primary and 84% in secondary cases. The median length of follow-up was 12.0 (7.0–18.0) and 10.0 (8.0–12.5) months in primary and secondary cases, respectively. The overall complication rate was 13% (2/15) (Clavien grade: 1–2).

Conclusions: The evaluation of the learning curve of RALP for this group of patients concluded that total operative time for RALP, performed by the pediatric urology team, steadily decreased with collective surgical experience.

Keywords: Learning curve, pediatric, pyeloplasty, robotics

Address for correspondence: Dr. Noor Nabi Junejo, Department of Urology, King Faisal Specialist Hospital and Research Centre, Riyadh, Saudi Arabia.
E-mail: drnoorjunejo@gmail.com

Received: 06.08.2019, **Accepted:** 21.11.2019, **Published:** 23.12.2019.

Video Available on: www.urologyannals.com

Access this article online	
Quick Response Code:	Website: www.urologyannals.com
	DOI: 10.4103/UA.UA_113_19

How to cite this article: Junejo NN, Alotaibi A, Alshahrani SM, Alshammari A, Peters CA, Alhazmi H, *et al*. The learning curve for robotic-assisted pyeloplasty in children: Our initial experience from a single center. Urol Ann 2020;12:19-24.

INTRODUCTION

The "gold standard" procedure for the correction of ureteropelvic junction obstruction (UPJO) has been the Anderson-Hynes dismembered pyeloplasty technique and open approach being the most common with success rates of 90%–100%, overall.[1,2] Now a day, there is an increasing trend towards the robotic approach to be a new gold standard option for the pediatric population as published in the literature[3] with similar outcomes as the open pyeloplasty.[4]

Robotic surgery in pediatrics urology has been gained popularity since its introduction almost two decades ago. Robotic-assisted pyeloplasty is the most common procedure performed in pediatric urology.[5] Robotic technology alleviates the limitations of conventional laparoscopic surgery, and the robot-assisted laparoscopic pyeloplasty (RALP) has to become the most common robotic surgery performed in pediatric urology.[6]

We conducted a retrospective study to determine the learning curve for pediatric urology team progression for surgical steps in performing robotic pyeloplasty. We define the learning curve as the improvement in total operative time.

We report our experience of 15 pediatric patients who underwent RALP between 2016 and 2017. The aim was to evaluate the progression of the surgical team performing RALP in a single Center and its recent introduction in the kingdom. Furthermore, to our knowledge, there is limited data on the learning curve internationally and no similar studies in Saudi Arabia.

SUBJECTS AND METHODS

After approval by the internal review board (IRB), we reviewed retrospectively the video records of RALP conducted in our center from January 2016 to October 2017.

We included cases between 2 and 15 years underwent RALP for primary and secondary UPJO; we exclude any case with concomitant other renal pathologies such as renal stone or ectopic kidney.

Patients' data were reviewed retrospectively for pre-, intra-, and postoperative details. Preoperative details included age, sex, type of UPJO, clinical presentation, renal ultrasonography for hydronephrosis grades, and type of nuclear scan. Intraoperative details included procedure performed, patient position and preparation, the introduction of trocars, robot docking, initial dissection and application of stay suture over the renal pelvis, pelvic opening, ureter spatulation, ureteropelvic anastomosis on each side, operative time, and any complication. Postoperative details included any immediate or late complication and length of hospital stay. Our primary the outcome measure was the success of the pyeloplasty as demonstrated by renal ultrasound and/or the resolution of the symptoms and the presence or absence of complications. The secondary outcome was total surgery time, which calculated in minutes. Renal ultrasound findings were reviewed for grades of hydronephrosis, according to the Society for Fetal Urology (SFU). Preoperatively we used diuretic renography to determine the severity and functional significance of UPJO. In most of the patients, we did Technetium-99 m mercaptoacetyltriglycine (^{99m}Tc-MAG-3) nuclear scan as it is ideal for the pediatric population.

We categorized the complications using the Clavien grading system as minor (Clavien 1–2) or major (Clavien 3–4).[3]

All procedures were done by primary pediatric urology as a team, with similar previous laparoscopic experience. The idea was to see how the robotic program has grown as one team in our center. Hence, it was an evolution as a team with at least two of three surgeons present in the operating room and sharing the console for all the cases. We have also included video to see the steps of robotic pyeloplasty [Video 1].

All the statistical analyses performed using the JMP Version 14 (SAS Institute, Cary, North Carolina) for Macintosh. Regression analysis was performed to find the trend of the time of the surgeries. Continuous variables were reported by mean values and 95% confidence intervals. $P < 0.05$ is considered to be statistically significant.

RESULTS

Fifteen pediatric patients presented with UPJO at out center who underwent RALP. Out of 15 cases, nine patients were primary and six cases as secondary UPJO (those who operated before). The demographic profile and preoperative details are shown in Table 1. We divided patients into two groups, i.e., primary versus secondary to review surgeons learning curve in different surgical steps. The median age was 8 (3–15) years. Patients presented with a history of flank pain, abdominal swelling, and worsening of hydronephrosis with impairment of renal functions in 60%, 26.7%, and 13.35 cases, respectively. Out of 15 cases, 13 and two patients diagnosed as SFU grade of 4 and 3, respectively. The intraoperative and postoperative results of primary and secondary cases are shown in Table 2. In our results, total operative time was prolonged in secondary pyeloplasty group as compared primary pyeloplasty group (mean [standard deviation (SD)]: 166.3 [35.1], range: 125–223, P = 0.0028 versus mean [SD]: 149.17 [30.4], range: 114–207, P = 0.0008). The success rate was 100% in primary and 84% in secondary cases. One patient of the secondary case was failed and further required redo pyeloplasty. We followed our patients every 6 months with a renal ultrasound and renal functions. The median length of follow-up was 12.0 (7.0–18.0) months and 10.0 (8.0–12.5) months in primary and secondary cases, respectively. The overall complication rate was 13% (2/15) (Clavien grade: 1–2), complaining of severe postoperative vomiting and managed conservatively. There was no intraoperative complication in either cohort [Table 2].

Table 1: Demographic profile and preoperative details

Variables	*n* (%)
Total number of patients	15
Median age (years)	8 (3–15)
Male	9 (60)
female	6 (40)
Clinical presentation number of cases (%)	
Pain	9/15 (60)
Abdominal swelling	4/15 (26.70)
Worsening of renal functions	2/15 (13.3)
Laterality (number of patients)	
Left	7 (47)
Right	8 (53)
Type of cases (Nos)	
Primary	9 (60)
Secondary	6 (40)
Grade of hydronephrosis (SFU) preoperative	
SFU Grade 4	13
SFU Grade 3	2
Preoperative nuclear scan	
MAG-3	11
DMSA	4

MAG-3: Mercaptoacetyltriglycine, DMSA: Dimercaptosuccinic acid, SFU: Society for fetal urology

Tables 3-5 show the descriptive analysis outcomes of all surgical steps for overall all cases, primary and secondary cases, respectively. There was a significant decrease in the total operation time overall of 40% from first to the last case with P = 0.260. The overall success rate was 94% in our study compared with other studies [Table 6].

Graphical presentation of outcomes for all cases, primary and secondary cases [Graphs 1-3 respectively] shows that there was an improvement in skills and the decrease in operative time with an increase in the number of cases, especially in primary cases, as we found postoperative adhesions in secondary cases and took longer time [Graphs 1-3].

DISCUSSION

RALP represents one of the modern and promising high-tech developments in the urological procedures for pediatrics. However, there are insufficient data about the learning curve of RALP in children. Our study represents one of the first studies from Saudi Arabia on the outcomes of the learning curve for RALP for the pediatric age group. This study resulted in RALP is feasible, potentially safe, satisfactory outcomes in terms of symptoms free, resolution/reduction of hydronephrosis grade, short hospital stays, and we found improvement in learning curve after 15 cases.

Table 2: Intraoperative and postoperative details of robotic-assisted laparoscopic pyeloplasty for primary and secondary ureteropelvic junction obstruction cases

Variable (time) min	Primary UPJO	Secondary UPJO	*P*
Number of patients	9/15	6/15	
Induction time, mean (SD) (range)	26.89.4 (2.76) (24.4–32)	25.83 (2.64) (22–30)	0.9326
Positioning and prep, mean (SD) (range)	27.78 (4.63) (20–33)	24.67 (2.58) (20.0–28)	0.0663
Total dissection and applying stay suture, mean (SD) (range)	26.17 (6.99) (17–37)	34.5 (6.89) (25–45)	0.0156
Renal pelvis opening and ureteric spatulation, mean (SD) (range)	39.22 (7.56) (30–55)	42.83 (10.62) (30–60)	0.0092
First side anastomosis, mean (SD) (range)	15.44 (7.14) (7–28)	20.83 (11.23) (9–38)	0.0213
Second side anastomosis, mean (SD) (range)	14.22 (6.98) (8–30)	17.67 (6.71) (11–30)	0.0630
Total surgery, mean (SD) (range)	140.17 (30.42) (114–207)	166.33 (35.16) (125–223)	0.0260
Crossing vessel	2	0	
Hospital stay (days) median	4.0 (3–4)	5.0 (4–6)	
Median follow-up, months (IQR)	12.0 (7.0–18.0)	10.0 (8.0–12.5)	0.311
Grade of hydronephrosis (SFU) postoperative			
SFU Grade 1	7/9	3/6	
SFU Grade 2	2/9	2/6	
SFU Grade 3		1/6 (failed)	
Complications (%)			
Intraoperative	0	0	
Postoperative	11	16	
Success rate (%)	100	84	

SD: Standard deviation, SFU: Society for fetal urology, UPJO: Ureteropelvic junction Obstruction, IQR: Interquartile range

Table 3: Time trend change over in all cases (*n*=15)

Variable time in minutes	Mean (SD)	Minimum	Maximum	Confidence Interval (95.0%)	Percentage time change	Percentage time change (last/first)	*r*	*P*
Induction time	26.46 (2.66)	22	32	−0.529-0.494	0	−12	−0.024	0.9326
Position prep time	26.53 (4.13)	20	33	−0.799-0.035	0	−13	−0.486	0.0663
Dissection time	14.53 (4.75)	8	22	−0.466-0.556	15	0	0.06	0.8281
Stay suture	2.70 (0.88)	2	5	−0.641-0.354	9	−33	−0.19	0.4911
Further dissection	12.47 (4.00)	7	20	−0.883-−0.256	−2	−61	−0.68	0.0053
Total dissection+stay suture	29.50 (7.92)	17	45	−0.706-0.247	6	−32	−0.30	0.2709
Renal pelvis open and ureteric spatulation	40.67 (8.87)	30	60	−0.87-−0.201	−1	−45	0.65	0.0092
First side anastomosis	17.60 (9.04)	7	38	−0.845-−0.107	16	−68	−0.59	0.0213
Second side anastomosis	15.60 (6.85)	8	30	−0.802-0.028	4	−63	−0.49	0.0630
Total surgery time	156.03 (32.34)	114	223	−0.838-−0.083	−1	−40	−0.57	0.0260

SD: Standard deviation

Table 4: Time trend change over in primary cases (*n*=9/15)

Variable time in minutes	Mean (SD)	Minimum	Maximum	Confidence Interval (95.0%)	Percentage time change	Percentage time change (last/first)	*r*	*P*
Induction time	26.89 (2.76)	24	32	−0.291-0.861	3	20	0.462	0.21
Position prep time	27.78 (4.63)	20	33	−0.99-−0.799	−5	38	−0.956	<0.0001
Dissection time	11.44 (2.92)	8	16	−0.973-−0.507	−8	−50	−0.87	0.002
Stay suture	2.77 (0.44)	2	3	−0.88-−0.177	−3	−33	−0.552	0.1233
Further dissection	12.56 (3.84)	7	18	−0.99-−0.809	−11	−61	−0.958	<0.0001
Total dissection + stay suture	26.17 (6.99)	17	37	−0.984-−0.67	−9	−54	−0.9235	0.0004
Renal pelvis open and ureteric spatulation	39.22 (7.56)	30	55	−0.976-−0.543	−7	−45	−0.887	0.0014
First side anastomosis	15.44 (7.14)	7	28	−0.98-−0.67	−16	−75	−0.923	0.0004
Second side anastomosis	14.22 (6.98)	8	30	−0.95-−0.19	13	−70	−0.759	0.0175
Total surgery time	149.17 (30.42)	114	207	−0.98-−0.599	−7	−45	−0.903	0.0008

SD: Standard deviation

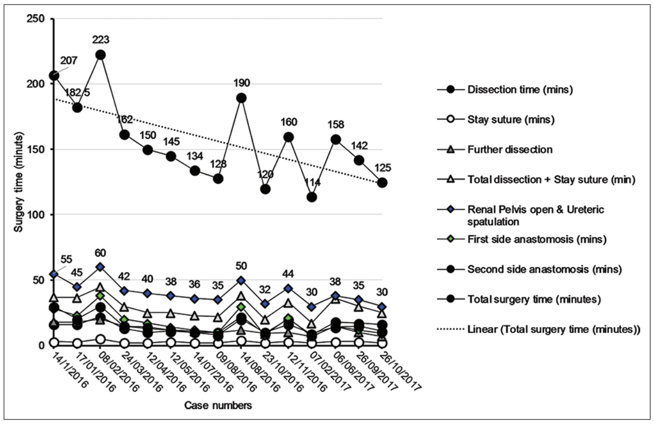
Table 5: Time trend change over in secondary cases (*n*=6/15)

Variable time in minutes	Mean (SD)	Minimum	Maximum	Confidence Interval (95.0%)	Percentage time change	Percentage time change (last/first)	*r*	*P*
Induction time	25.83 (2.64)	22	30	−0.867-0.736	−2	−12	−0.188	0.7220
Position prep time	24.67 (2.58)	20	28	−0.625-0.91	3	12	0.378	0.4594
Dissection time	19.17 (2.56)	16	22	−0.99-−0.72	−6	−27	−0.967	0.0016
Stay suture	3.33 (1.03)	2	5	−0.99-−0.36	−16	−60	−0.907	0.0126
Further dissection	12.33 (4.58)	7	20	−0.97-0.20	−14	−65	−0.728	0.1003
Total dissection + stay suture	34.5 (6.89)	25	45	−0.99-−0.31	−11	−44	−0.896	0.0156
Renal pelvis open and ureteric spatulation	42.83 (10.92)	30	60	−0.99-−088	−13	−50	−0.986	0.0003
First side anastomosis	20.83 (11.23)	9	38	−0.99-−0.86	−25	−76	−0.985	0.0003
Second side anastomosis	17.67 (6.71)	11	30	−0.99-−0.36	−17	−63	−0.908	0.0123
Total surgery time	166.33 (35.16)	125	223	−0.96-−0.99	−11	−44	−0.957	0.0028

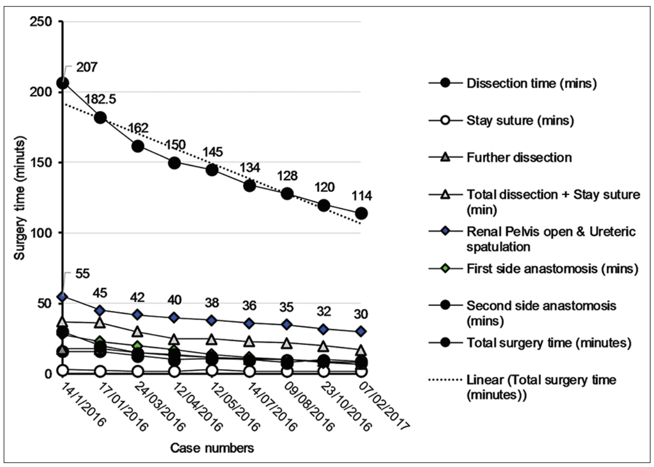
Table 6: Robotic-assisted laparoscopic pyeloplasty: Outcomes of comparative studies

Study	Year	Study type	Patients	Success rate (%)	Complication rates (%) definition	Mean OT (min)
Olsen *et al.*[7]	2007	Case series	67	94	13.8 OC	143 (93-300)
Franco *et al.*[8]	2007	Comparative	15	100	Not reported	236
Sorensen *et al.*[9]	2011	Comparative	33	97	15.0 OC	326
Subotic *et al.*[10]	2011	Comparative	19	100	28.0 OC	165
Barbosa *et al.*[11]	2012	Comparative	58	74	1.7 (needed redo pyeloplasty)	-
Riachy *et al.*[12]	2012	Comparative	46	100	4.0 OC	209
Salö *et al.*[13]	2016	Comparative	39	96	3.2 (Grade 3 complication)	-
Kassite *et al.*[14]	2018	Case series (interphase comparisons)	39	95 phase 1 94 phase 2	19 (phase 1and 2) 17 (phase 3)	200
Morales-López *et al.*[5]	2019		41	95	9.7	135
Present study	2019	Case series	15	94	13.0 OC	156 (114-223)

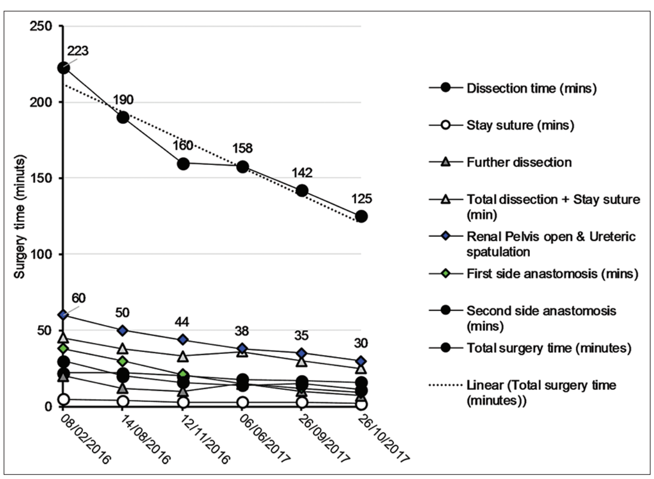
OT: Operative time, OC: Overall complications



Graph 1: Graphical representation for all cases



Graph 2: Graphical representation for primary cases



Graph 3: Graphical representation for secondary cases

The learning curve for RALP in the management of pediatric urology patients has reported in the literature.[9,15]

The robotic tools allow for three-dimensional imaging, motion scaling, tremor sifting, an ergonomic installed position, and wrist movement allowing autonomy of up to 7° comparable to open surgical instruments. Subsequently, the system is proficient in producing very subtle changes, perfect for urologic surgery within the smaller pediatric patient. Furthermore, these robotic properties have expressively reduced the learning curve for intracorporeal suturing compared to conventional laparoscopy.[16]

A smaller learning curve permits further surgeons to offer a minimally invasive method to the pyeloplasty, reduces operating room times and subsequent cost, and decreases the risk of complications in patients as the surgeon obtains the skill. O'Brien and Shukla[17] have shown a shortened learning curve for the robotic pyeloplasty, presenting that it needs diminutive previous laparoscopic or robotic experience and established in comparing outcomes, analgesic requirements, and length of stay with age-matched laparoscopic and open patients from the pediatric literature.[17]

We reported our initial experience of 15 RALP cases in pediatric patients. Sorensen *et al*.[9] evaluated the learning curve and outcomes, comparing RALP against the open approach. Similar results reported between the two procedures after approximately twenty cases, which is a much-shortened course compared to the vertical learning curve for laparoscopy. Therefore, in adding to its efficacy in smaller patients, RALP may be stress-free to learn compared to conventional laparoscopic pyeloplasty, increasing access to minimally invasive methods in the field of pediatric urology.

Tasian *et al*.[15] reported the learning curve of robotic pyeloplasty for children with UPJO. They observed an improvement of 3.7 minutes per case with excellent surgical outcomes. Authors[18] understood that if surgical time is used to define the learning curve, it must be measured accompanied by the surgical outcomes. Surgical simulation has the potential to develop patient safety, increase surgical training competence, and to lessen operating room expenditures.[18]

To manage the secondary (recurrent) UPJO after primary pyeloplasty poses a substantial surgical challenge, particularly in complex cases. In our study, total operative time was prolonged in the secondary pyeloplasty group as compared primary pyeloplasty group (mean [SD]: 166.3 [35.1], range: 125–223, $P = 0.0028$ versus mean [SD]: 149.17 [30.4], range: 114–207, $P = 0.0008$.

Sorensen *et al*.[9] reported that after 15–20 robotic cases, the overall operative time for RALP cases was constantly within 1 SD of average open pyeloplasty time with no significant variance in complete operative time ($P = 0.23$) and concluded that operative time decreased after gaining more experience.

Recently, Kassite *et al*.[14] has conducted a study on the learning curve of RALP in children: a multi outcome approach. They enrolled patients such as 1–12, 13–22, and 2–39 cases in Phase 1, 2, and 3 and three periods (learning, consolidation and increased competence), respectively. The interphase evaluation indicated a substantial decrease in operation time, length of stay, and postoperative pain ($P = 0.0001$; $P = 0.0076$; $P = 0.039$), respectively. Results showed a mean operation time was mean (SD) 200 (72.8) min. They concluded that more complex features impact surgical outcomes. Table 6 shows the comparative operation time results.

Thom *et al*.[19] performed a study on robotic-assisted pyeloplasty to review the outcomes for primary and secondary repairs. They included 55 patients who underwent RAP 926 left/29 right for UPJO, which included 46 primaries and 9 secondary cases. The mean operative time was 194 min, and they found lengthier time for secondary cases 205 min.

Success rates and complications: in our study, the overall complication rate was 13% (2/15) (Clavien grade: 1–2). Moreover, the overall success rate was 94% (14/15). We compared the success rates and complications with other studies [Table 6].

Limitations

Our study has limitations: (1) Retrospective study and (2) single-center experience of RALP; hence a much broader picture of the status of RALP in Saudi Arabia is yet to be defined and addressed through Multi-Institutional Study.

CONCLUSIONS

The evaluation of the learning curve of RALP for this group of patients showed that total operative time for RALP, performed by the pediatric urology team, steadily decreased with collective surgical experience. As a result, surgeons with limited laparoscopic experience can more readily acquire surgical skills, and the utilization of RALP is growing rapidly, signifying that the robotic approach may be the new gold standard for minimally invasive pyeloplasty; however, further studies need to publish from Saudi Arabia.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Patel, NS, Muneer A, Mushtaq I. Laparoscopy as a foundation and its limitations and pitfalls in reconstructive paediatric urology. In: Gundeti MS, editor. Pediatric Robotic and Reconstructive Urology: A Comprehensive Guide. Chichester: Blackwell Publishing Ltd., UK; 2012.s p. 51-7.
2. Carr MC, Casale P. Anomalies and surgery of the ureter in children. In: Wein AJ, editor. Campbell-Walsh Urology. Vol. 4. Philadelphia: Elsevier Saunders Publishers, USA; 2012. p. 3212-35.
3. Clavien PA, Barkun J, de Oliveira ML, Vauthey JN, Dindo D, Schulick RD, *et al*. The Clavien-Dindo classification of surgical complications: Five-year experience. Ann Surg 2009;250:187-96.
4. Peters CA. Robotic pyeloplasty--the new standard of care? J Urol 2008;180:1223-4.
5. Morales-López RA, Pérez-Marchán M, Pérez Brayfield M. Current concepts in pediatric robotic assisted pyeloplasty. Front Pediatr 2019;7:4.
6. Varda BK, Johnson EK, Clark C, Chung BI, Nelson CP, Chang SL. National trends of perioperative outcomes and costs for open, laparoscopic and robotic pediatric pyeloplasty. J Urol 2014;191:1090-5.
7. Olsen LH, Rawashdeh YF, Jorgensen TM. Pediatric robot assisted retroperitoneoscopic pyeloplasty: A 5-year experience. J Urol 2007;178:2137-41.
8. Franco I, Dyer LL, Zelkovic P. Laparoscopic pyeloplasty in the pediatric patient: Hand sewn anastomosis versus robotic assisted anastomosis – Is there a difference? J Urol 2007;178:1483-6.
9. Sorensen MD, Delostrinos C, Johnson MH, Grady RW, Lendvay TS. Comparison of the learning curve and outcomes of robotic assisted pediatric pyeloplasty. J Urol 2011;185:2517-22.
10. Subotic U, Rohard I, Weber DM, Gobet R, Moehrlen U, Gonzalez R. A minimal invasive surgical approach for children of all ages with ureteropelvic junction obstruction. J Pediatr Urol 2012;8:354-8.
11. Barbosa JA, Kowal A, Onal B, Gouveia E, Walters M, Newcomer J, *et al*. Comparative evaluation of the resolution of hydronephrosis in children who underwent open and robotic-assisted laparoscopic pyeloplasty. J Pediatr Urol 2013;9:199-205.
12. Riachy E, Cost NG, Defoor WR, Reddy PP, Minevich EA, Noh PH. Pediatric standard and robot-assisted laparoscopic pyeloplasty: A comparative single institution study. J Urol 2013;189:283-7.
13. Salö M, Sjöberg Altemani T, Anderberg M. Pyeloplasty in children: Perioperative results and long-term outcomes of robotic-assisted laparoscopic surgery compared to open surgery. Pediatr Surg Int 2016;32:599-607.
14. Kassite I, Braik K, Villemagne T, Lardy H, Binet A. The learning curve of robot-assisted laparoscopic pyeloplasty in children: A multi-outcome approach. J Pediatr Urol 2018;14:570.e1-10.
15. Tasian GE, Wiebe DJ, Casale P. Learning curve of robotic assisted pyeloplasty for pediatric urology fellows. J Urol 2013;190:1622-6.
16. Calatayud D, Arora S, Aggarwal R, Kruglikova I, Schulze S, Funch-Jensen P, *et al*. Warm-up in a virtual reality environment improves performance in the operating room. Ann Surg 2010;251:1181-5.
17. O'Brien ST, Shukla AR. Transition from open to robotic-assisted pediatric pyeloplasty: A feasibility and outcome study. J Pediatr Urol 2012;8:276-81.
18. Kilic GS, Walsh TM, Borahay M, Zeybek B, Wen M, Breitkopf D. Effect of residents' previous laparoscopic surgery experience on initial robotic suturing experience. ISRN Obstet Gynecol 2012;2012:569456.
19. Thom MR, Haseebuddin M, Roytman TM, Benway BM, Bhayani SB, Figenshau RS. Robot-assisted pyeloplasty: Outcomes for primary and secondary repairs, a single institution experience. Int Braz J Urol 2012;38:77-83.