J Robotic Surg (2014) 8:365–369
DOI 10.1007/s11701-014-0481-0

ORIGINAL ARTICLE

Proctor environment facilitates faculty training in pediatric robotic-assisted laparoscopic pyeloplasty

Matthew D. Mason · C. D. Anthony Herndon · Katherine W. Herbst · Tyler L. Poston · Elizabeth J. Brandt · Craig A. Peters · Sean T. Corbett

Received: 16 June 2014 / Accepted: 27 July 2014 / Published online: 14 August 2014

Abstract At our institution, faculty surgeons newly practicing robotic surgery are proctored by an expert surgeon for a minimum of three cases before operating independently. Our study evaluates the effectiveness of this proctor environment on the learning curve of faculty pediatric urologists training to perform robotic-assisted laparoscopic (RAL) pyeloplasty. We reviewed all pediatric RAL pyeloplasties performed at our institution between June 2006 and September 2012, comparing procedures performed by expert surgeon (E) and two training surgeons (both previously experienced laparoscopic surgeons). Training surgeons were proctored for at least three cases before able to operate on their own. Learning curve was quantified by benchmarking training surgeons' post-proctored operative times to E's mean operative time. One hundred and thirty-four RAL pyeloplasties were performed during the time period. Mean operative time was 3:31 h from start of cystoscopy to dressing placement. Both training surgeons achieved E's mean operative time by their fourth case. The transition from laparoscopic pyeloplasty to RAL pyeloplasty for faculty surgeons in a proctor environment results in a more rapid achievement of benchmark levels than previously described for a new learner. The dual module da Vinci® Si surgical system may expedite this process further with the operative surgeon acting as a true "co-pilot".

Keywords Pediatric · Pyeloplasty · Robotic · UPJ obstruction · Minimally invasive · Learning curve

Abbreviations

E	Expert surgeon
T1	Training surgeon 1
T2	Training surgeon 2
RAL	Robotic-assisted laparoscopic
RALP	Robotic-assisted laparoscopic pyeloplasty
UPJO	Ureteropelvic junction obstruction

M. D. Mason · C. D. A. Herndon ·
T. L. Poston · E. J. Brandt · C. A. Peters · S. T. Corbett
Department of Urology, University of Virginia Health System,
P.O. Box 800422, Charlottesville, VA 22908, USA
e-mail: cah7cc@virginia.edu

T. L. Poston
e-mail: tlposton@uab.edu

E. J. Brandt
e-mail: elizabeth.brandt@northwestern.edu

C. A. Peters
e-mail: crpeters@childrensnational.com

S. T. Corbett
e-mail: stc2u@virginia.edu

Present Address:
M. D. Mason (✉)
Vanderbilt University - Pediatric Urology, A-1302 Medical
Center North, Nashville, TN 37232-2765, USA
e-mail: matthew.d.mason@vanderbilt.edu

K. W. Herbst
Connecticut Children's Medical Center, 282 Washington Street,
Hartford, CT 06106, USA
e-mail: kherbst@connecticutchildrens.org

C. A. Peters
Sheikh Zayed Institute for Pediatric Surgical Innovation,
Children's National Medical Center, 111 Michigan Ave NW,
Washington, DC 20010, USA

Introduction

In the pediatric population, robotic-assisted laparoscopic pyeloplasty (RALP) is being increasingly utilized for the treatment of ureteropelvic junction obstruction (UPJO) [2–7]. There have been numerous studies in the adult literature to evaluate the learning curve of RAL adult procedures [8–14], but few studies evaluating pediatric RALP. A study by Sorensen et al. [2] compared RALP cases performed at their institution to previously performed open pyeloplasty cases, finding similar outcomes but a longer mean operative time for RALP. They were able to quantify a learning curve of 15–20 cases, after which operative time for RALP was within 1 SD of mean open pyeloplasty operative time [2]. A recent study by Tasian et al. [3] evaluated operative times of pediatric urology fellows performing RALP, finding an average decrease in operative time of 3.7 min per case, projecting it would take 37 cases to achieve the same operative time as that of the attending surgeon.

At our institution, new robotic faculty surgeons are trained in a proctor environment, with an expert surgeon proctoring a trainee faculty surgeon for a minimum of three cases prior to his performing robotic-assisted surgery independently. The aim of our study is to determine the effectiveness of this proctor environment on the learning curve, as measured by operative time for a standard procedure, of faculty pediatric urologists training to perform RALP.

Patients and methods

After Institutional Review Board approval, all RALP's performed at our institution between June 2006 and September 2012 were retrospectively reviewed. Procedures were performed by three pediatric urologists; an expert surgeon [CAP (E)], and two training surgeons [STC (T1), CAH (T2)]. Both training surgeons had extensive previous laparoscopic experience, but neither had prior robotic experience. T1 surgeon had just completed pediatric urology fellowship training with a wide variety of laparoscopic procedures such as partial nephrectomy, transplant donor nephrectomy, ureteral reimplantation and others, having completed over 20 laparoscopic pyeloplasty procedures. T2 surgeon had been practicing as a pediatric urologist for several years, using laparoscopy for a wide range of abdominal procedures. During the last 3 years of his busy practice, he exclusively used the laparoscopic approach for upper pole heminephrectomies and dismembered pyeloplasties, performing 36 laparoscopic pyeloplasties prior to this study.

A proctor environment was established at our institution in which a minimum of three cases were supervised by a proctor surgeon before a surgeon in training performed cases on his own. Additional proctored procedures were performed if either the proctor or the training surgeon felt more cases were needed to establish competency.

Criteria for pyeloplasty were diuretic renography indicative of poor radionuclide washout with diminished ipsilateral relative renal function (<40 %), exacerbation of hydronephrosis, clearly symptomatic hydronephrosis (as demonstrated by increased hydronephrosis during an episode of ipsilateral renal colic), renal stone(s), or febrile urinary tract infections associated with a system with radiographic concern for UPJO. Initial cases in the series were performed using the da Vinci® Standard surgical system, and later cases were performed using the da Vinci® Si surgical system after this was purchased by our institution in July 2010. Procedures were performed using a 12 mm camera port, and either two 5 mm or two 8 mm working ports (8 mm ports were utilized in larger children or when 5 mm ports were unavailable). In all cases, a ureteral stent and a urethral catheter were left in place. In some patients, a cystoscopy with retrograde placement of the ureteral stent was utilized, whereas other cases utilized a 14-French angiocatheter for antegrade placement of the stent.

In order to determine effectiveness of the proctoring program, operative time, intra-operative and post-operative complications, and length of stay were compared. Effectiveness was further examined by benchmarking both proctored surgeon's operative times to the average ± SD overall operative time of the expert surgeon. As patient weight may be associated with variation in operative time, the expert surgeon's cases were matched to each training surgeon's cases by weight at surgery for the benchmarking analysis.

Operative time was defined as time of start of cystoscopy or first incision to time of dressing placement. Patients were excluded from operative time and benchmark analysis if they received concurrent bilateral repair ($n = 1$), underwent other concurrent procedures ($n = 12$), had received a prior pyeloplasty procedure ($n = 5$), had both concurrent procedures and prior pyeloplasty procedures ($n = 2$), or had an intra-operative complication ($n = 1$). Complications were defined as any operative or post-operative complications reported in the patient's record and were classified using the Clavien–Dindo classification of surgical complications [1].

Data analysis was performed using SPSS 17.0 (IBM Corporation, Armonk, New York). Categorical variables were compared by Fisher's exact test using the Bonferroni adjustment, and continuous variables compared using one-way analysis of variance (ANOVA) followed by Bonferroni post hoc test or Kruskal–Wallis test followed by Mann–Whitney U using the Bonferroni adjustment. Comparative statistical tests were two-tailed with a p value of <0.05 considered significant.

Table 1 Patient characteristics by surgeon

Characteristic	Expert	Training 1	Training 2	p value
No. of patients, % (n)	61 % (82)	31 % (41)	8 % (11)	
Gender, % (n)				1.00[a]
Male	67 % (55)	68 % (28)	73 % (8)	
Female	33 % (27)	32 % (13)	27 % (3)	
Age at surgery, mos, median (range)	48 (3–240)	20 (7.5–78)	60 (6–204)	<0.05[b]
Weight at surgery, kg, median (range)	18 (6–156)	12 (6–66)	22 (7–74)	<0.005[b]
Laterality, % (n)				1.00[a]
Left	59 % (48)	58 % (24)	64 % (7)	
Right	40 % (33)	42 % (17)	36 % (4)	
Bilateral	1 % (1)	–	–	
Co-existing GU diagnosis, % (n)				0.89[a]
Yes	7 % (6)	10 % (4)	9 % (1)	
No	93 % (76)	90 % (37)	91 % (10)	

[a] Fisher's exact test

[b] Kruskal–Wallis test

Results

There were 134 RAL pyeloplasty cases at our institution from 2006 to 2012. The majority of surgeries were performed by the E surgeon (61 %), followed by T1 surgeon (31 %), and T2 surgeon (8 %). The E surgeon's patients were significantly older ($p = 0.014$) and weighed more ($p = 0.01$) at surgery than those of T1. There was no significant difference in age or weight at surgery between T1 and T2; however, this may have been due to T2's limited sample size. Otherwise, the cohort was statistically similar in gender, laterality, and co-existing urologic conditions among the three surgeons (Table 1). Concurrent procedures performed for co-existing urologic conditions include inguinal hernia repair, umbilical hernia repair, circumcision, orchiopexy, and ureteral dilation.

Overall, most of the pyeloplasties (80 %) were performed using the da Vinci® Standard surgical system. The E surgeon performed significantly more procedures with the standard system than either of the training surgeons ($p < 0.001$ T1, T2). T2 surgeon placed more stents antegrade than either E ($p < 0.001$) or T1 ($p = 0.01$), but T2 did still perform cystoscopy and retrograde pyelography prior to laparoscopy in all cases. The number of cases with prior pyeloplasty surgery and the experience of the resident assisting with the case were similar among all surgeons (Table 2).

The E surgeon's mean operative time was significantly shorter than either T1 ($p < 0.05$) and T2 ($p < 0.001$), and T1's mean operative time was significantly shorter than T2's operative time ($p < 0.01$). There was no difference between the three surgeons for the remaining effectiveness measures (Table 3).

As the E surgeon represented a substantial number of cases in this series, it was possible to weight match to the training surgeon's cases for benchmarking purposes as there was a significant difference in age and weight between E and T1/T2 patients. After weight matching, the median weight for T1 was 14 kg (range 7–66) and E was 14 kg (range 6–65) within the weight-matched subgroup for T1 ($n = 35$). The median weight for T2 was 22 kg (range 7–74) and E was 23 kg (range 7–75) within the weight-matched subgroup for T2 ($n = 10$). When these subgroups were analyzed chronologically, the T1 surgeon's post-proctored operative time reached within 1 SD of the E's weight-matched average operative time by the fourth case. The T2's proctored operative time reached within 1 SD of the E's weight-matched average operative time also by the fourth case. Figure 1 illustrates operative time per case for the T1 and T2 subgroups, as compared to E's weight-matched average overall operative time.

Table 2 Operative characteristics by surgeon

Characteristic	Expert	Training 1	Training 2	p value
Robot type, % (n)				<0.001[a]
da Vinci® Standard	99 % (81)	24 % (10)	–	
da Vinci® Si	1 % (1)	76 % (31)	100 % (11)	
Prior pyeloplasty, % (n)				0.16[a]
Yes	7 % (6)	–	9 % (1)	
No	93 % (76)	100 % (41)	91 % (10)	
Stent placement, % (n)				0.001[a]
Retrograde	83 % (68)	73 % (30)	27 % (3)	
Antegrade	17 % (14)	27 % (11)	73 % (8)	
Surgical assistant				0.53[a]
Chief resident	78 % (64)	73 % (30)	91 % (10)	
Junior resident	24 % (18)	27 % (11)	9 % (1)	

[a] Fisher's exact test

Table 3 Operative outcomes by surgeon

Characteristic	Expert	Training 1	Training 2	*p* value
Operating time, h:mm, mean (SD)	3:18 (0:40)	3:41 (0:40)	4:26 (0:47)	<0.001[a]
Surgical complications, % (*n*)				0.39[b]
Yes	3 % (2)	9 % (4)	18 % (2)	
No	97 % (78)	91 % (38)	82 % (9)	
Length of stay, % (*n*)				0.14[b]
1 day	57 % (46)	76 % (32)	91 % (10)	
2 days	34 % (27)	12 % (5)	–	
3 or more days	9 % (7)	12 % (5)	9 % (1)	
Length of stay (days), median (range)	1 (1–8)	1 (1–5)	1 (1–4)	0.08[c]

[a] ANOVA

[b] Fisher's exact test

[c] Kruskal–Wallis test

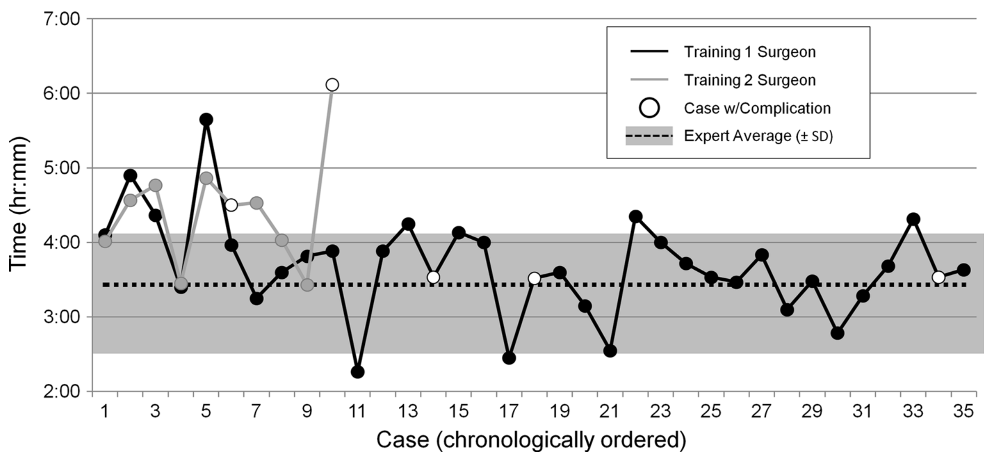

Fig. 1 Training surgeons' weight-matched operative times benchmarked to expert surgeon's average overall operative time

Discussion

The patient populations of the three surgeons were similar, with a few significant differences. Robot type also differed among the three surgeons, with virtually all of the expert surgeon's cases performed on the da Vinci® Standard (99 %). The training surgeons predominantly used the da Vinci® Si for their cases (T1 = 76 %, T2 = 100 %). Both E and T1 placed the majority of stents in a retrograde fashion, and T2 placed the majority of stents in an antegrade fashion. Antegrade stent placement may take less time than retrograde stent placement, but T2 did still perform cystoscopy and retrograde pyelography prior to laparoscopy which would make overall operative time similar to procedures including retrograde stent placement. All other patient characteristics were similar among the three surgeons.

T1 appeared to have a rapid achievement of benchmark levels, with post-proctored operative time reaching within 1 SD of E's mean operative time by his third case. The learning curve for T2 was also rather quick, with the operative time for T2 reaching within 1 SD of E's mean operative time by his fourth case.

All surgeons had similar numbers of complications and length of stay. Complications among T1's patients occurred after the proctoring period, and were reported for his 15th, 19th, 30th and 36th cases. These were all cases of post-operative ileus which were managed conservatively (Clavien grade I) [1]. T2's complications were reported for his 6th and 10th cases. One of these was a case of post-operative ileus managed conservatively (Clavien grade I). The other was a 16-month-old with a very narrow ureteral orifice through which a guide wire was able to be placed along the entire ureter, but a double-J ureteral stent could not be placed either retrograde or antegrade. A cutaneous pyeloureteral catheter was placed for this patient, but this catheter stopped draining on the third post-operative day. The catheter was made functional again with a slight adjustment under fluoroscopy without anesthesia (Clavien grade IIIa). Expert's complications were reported for his 48th and 55th cases. One of these was a patient with a non-functioning stent that later required percutaneous nephrostomy tube placement (Clavien grade IIIb). The other patient developed a urine leak that was managed with stent exchange and paracentesis (Clavien grade IIIb). Including even minor deviations from the standard post-operative course (Clavien grade I), the complication rate for E (3 %) and T1 (9 %) were within the range reported in other series of 3–12.5 %, while the complication rate for T2 (20 %) was higher than previously reported [3–6]. Including only

Clavien grade II or higher complications, all surgeons had complication rates at or below the previously reported ranges.

The study by Sorensen et al. [2] showed that after 15–20 robotic cases, operative times were consistently within 1 SD of mean operative time for open pyeloplasty. Our study shows similar findings with T1 surgeon's operative times reaching within 1 SD of E surgeon's mean operative time by his third case. However, this study may be better suited to evaluate the ability to achieve benchmark levels for robotic surgery by using as its benchmark mean operative time of an expert robotic surgeon rather than mean operative time of open surgery.

The study by Tasian et al. [3] showed that operative time for pediatric urology fellows in training decreases by an average of 3.7 min per case, with a projected achievement of operative time equal to the attending surgeon at the 37th case. Our study shows more rapid achievement of operative time equal to E surgeon, but our training surgeons were both attending surgeons with extensive prior laparoscopic surgical experience.

Our study does have limitations. As a retrospective study, it is subject to the inherent limitations of any retrospective study design. Our measure of achievement of benchmark levels is based mainly on operative time, and we did not evaluate patient outcomes with regard to resolution of symptoms or hydronephrosis. A future study which includes long-term patient outcomes will be essential in determining if training surgeons are able to provide surgical treatment which is not only timely, but effective as well. T2 surgeon had a small sample size of cases, and had not yet performed adequate cases beyond the proctor period for analysis. This study did not measure how much of each procedure is performed by the resident surgeon. The E and T1 surgeons roughly estimate that ~40 % of the case based on time is performed by the resident. Finally, our achievement of benchmark findings are only based on the experience of one expert surgeon, and further evaluation in future series would prove helpful.

Conclusions

The transition from laparoscopic pyeloplasty to RALP for faculty surgeons in a proctor environment results in a more rapid achievement of benchmark levels than previously described for a new learner, with high success and minimal complications. The dual module da Vinci® Si surgical system expedites this process further with the operative surgeon acting as a true "co-pilot".

Conflict of interest Matthew D. Mason, C. D. Anthony Herndon, Katherine W. Herbst, Tyler L. Poston, Elizabeth J. Brandt, Craig A. Peters, and Sean T. Corbett declare that they have no conflict of interest.

Ethical standard This project met criteria for ethical approval by our Institutional Review Board. All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000. It was the determination of the Institutional Review Board at our institution that informed consent from patients was not required for this retrospective study.

References

1. Dindo D, Demartines N, Clavien PA (2004) Classification of surgical complications. Ann Surg 240(2):205–213
2. Sorensen MD, Delostrinos C, Johnson MH, Grady RW, Lendvay TS (2011) Comparison of the learning curve and outcomes of robotic assisted pediatric pyeloplasty. J Urol 185(6 Suppl):2517–2522. doi:10.1016/j.juro.2011.01.021
3. Tasian GE, Wiebe DJ, Casale P (2013) Learning curve of robotic assisted pyeloplasty for pediatric urology fellows. J Urol 190(4 Suppl):1622–1626. doi:10.1016/j.juro.2013.02.009
4. Yee DS, Shanberg AM, Duel BP, Rodriguez E, Eichel L, Rajpoot D (2006) Initial comparison of robotic-assisted laparoscopic versus open pyeloplasty in children. Urology 67(3):599–602
5. Singh P, Dogra PN, Kumar R, Gupta NP, Nayak B, Seth A (2012) Outcomes of robot-assisted laparoscopic pyeloplasty in children: a single center experience. J Endourol 26(3):249–253. doi:10.1089/end.2011.0350
6. Lee RS, Retik AB, Borer JG, Peters CA (2006) Pediatric robot-assisted laparoscopic dismembered pyeloplasty: comparison with a cohort of open surgery. J Urol 175:683–687
7. Mufarrij PW, Woods M, Shah OD, Palese MA, Berger AD, Thomas R, Stifelman MD (2008) Robotic dismembered pyeloplasty: a 6-year, multi-institutional experience. J Urol 180(4):1391–1396. doi:10.1016/j.juro.2008.06.024
8. Patel VR, Tully AS, Holmes R, Lindsay J (2005) Robotic radical prostatectomy in the community setting-the learning curve and beyond: initial 200 cases. J Urol 174(1):269–272
9. Doumerc N, Yuen C, Savdie R, Rahman MB, Rasiah KK, Pe Benito R, Delprado W, Matthews J, Haynes AM, Stricker PD (2010) Should experienced open prostatic surgeons convert to robotic surgery? The real learning curve for one surgeon over 3 years. BJU Int 106(3):378–384. doi:10.1111/j.1464-410X.2009.09158.x
10. Herrell SD, Smith JA Jr (2005) Robotic-assisted laparoscopic prostatectomy: what is the learning curve? Urology 66(5 Suppl):105–107
11. Pruthi RS, Smith A, Wallen EM (2008) Evaluating the learning curve for robot-assisted laparoscopic radical cystectomy. J Endourol 22(11):2469–2474. doi:10.1089/end.2008.0320
12. Haseebuddin M, Benway BM, Cabello JM, Bhayani SB (2010) Robot-assisted partial nephrectomy: evaluation of learning curve for an experienced renal surgeon. J Endourol 24(1):57–61. doi:10.1089/end.2008.0601
13. Bell MC, Torgerson JL, Kreaden U (2009) The first 100 da Vinci hysterectomies: an analysis of the learning curve for a single surgeon. S D Med 62(3):91, 93–95
14. Seamon LG, Fowler JM, Richardson DL, Carlson MJ, Valmadre S, Phillips GS, Cohn DE (2009) A detailed analysis of the learning curve: robotic hysterectomy and pelvic-aortic lymphadenectomy for endometrial cancer. Gynecol Oncol 114(2):162–167