Pediatric Partial Nephrectomy for Upper Urinary Tract Duplication Anomalies: A Comparison Between Different Surgical Approaches and Techniques

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OBJECTIVE To review and compare 4 different surgical approaches for partial nephrectomy of a nonfunctioning moiety in children with upper urinary tract duplication anomalies.

MATERIALS AND METHODS A retrospective review of all pediatric patients who underwent open partial nephrectomy (OPN), laparoscopic partial nephrectomy (LPN), robotic partial nephrectomy (RPN), or laparoendoscopic single site partial nephrectomy (LESS-PN) for the treatment of a nonfunctioning moiety in a duplicated collecting system at 2 medical centers between 2007 and 2017. Patient demographics, perioperative data, surgical techniques, complications, and results were compared.

RESULTS A total of 59 pediatric patients underwent partial nephrectomy for an upper urinary tract duplication anomaly during a 10-year period: 24 OPN, 7 LPN, 18 RPN, and 10 LESS-PN. Median age was 16 months (interquartile range 9-49.7). Median weight was 10.7 Kg (interquartile range 8.8-16.4). Median estimated blood loss was comparable between all minimally invasive approaches, but significantly increased in the open approach. OPN required more narcotics (0.554 mg Morphine equivalent/Kg/day, range 0.03-6.13) and Acetaminophen (72.12 mg/Kg/day, range 0-209.06) than all other groups in the study. Median operating time in OPN (154.5 minutes, range 108-413) and LESS-PN (140 minutes, range 65-245) were found to be significantly shorter in comparison to LPN (190 minutes, range 159-355), and RPN (256 minutes, range 163-458); (P = .03, .005, .02, and .005).

CONCLUSION Minimally invasive approaches (LPN, RPN, and LESS-PN) for partial nephrectomy in upper urinary tract duplication anomalies may be associated with decreased postoperative analgesia requirements, shorter hospital stay, less blood loss, and less use of drains in comparison to the open approach, while demonstrating efficacy and safety. UROLOGY 125: 196–201, 2019. © 2018 Elsevier Inc.

Upper urinary tract duplication anomalies are a congenital condition occurring in 1% of the population. The rationale for performing partial nephrectomy of a nonfunctioning moiety is reduction of morbidity secondary to recurrent infection, flank/abdominal pain, or incontinence.[1] Since the first report of laparoscopic partial nephrectomy for duplication anomalies by Jordan and Winslow,[2] minimally invasive approaches have gained popularity, and in some centers, has replaced open surgery for the surgical management of urinary tract abnormalities. More advanced minimally invasive techniques, such as the robotic and the LaparoEndoscopic Single Site partial nephrectomy have also been reported for treatment of urinary tract abnormalities.[3,4] Alternative treatment methods such as Laparoscopic upper pole ureteral ligation[5] and distal Ureteroureterostomy[6] for the treatment of symptomatic duplication anomalies have been well described before, however require specific conditions such as lack of lower pole reflux. The small number of studies and potential for postoperative complications such as flank pain due to increased hydronephrosis and infection have precluded these methods from becoming the standard of care. Partial nephrectomy is considered the gold standard for treatment of a symptomatic

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nonfunctioning moiety in a duplication anomaly, however, there is a paucity of studies comparing the different approaches for partial nephrectomy. The aim of this study was to review and compare outcomes between 4 different partial nephrectomy approaches: open partial nephrectomy (OPN), laparoscopic partial nephrectomy (LPN), robotic partial nephrectomy (RPN), and LaparoEndoscopic Single Site partial nephrectomy (LESS-PN), for the surgical management of a nonfunctioning moiety in upper urinary tract duplication anomalies in the pediatric population.

MATERIALS AND METHODS

Study Population and Design

A retrospective review was performed for patients under 18 years of age who underwent partial nephrectomy for an upper urinary tract duplication anomaly at 2 medical centers from 2007 to 2017. A total of 59 patients were identified: 24 OPN, 7 LPN, 18 RPN, and 10 LESS-PN. Indications for surgical intervention included a nonfunctioning moiety combined with one or more clinical problems: recurrent urinary tract infection, urinary incontinence, flank pain, or hypertension. Partial nephrectomy for other indications were excluded from this study. Partial nephrectomy was performed by 5 surgeons. LPN was performed by 3 surgeons, RPN was performed by 4 surgeons, and LESS-PN was performed by 1 surgeon. Surgical approach was based on surgeon preference and was not based on clinical presentation. Minimally invasive procedures were more prevalent later in the study period as would be expected with evolving practice patterns and introduction of new technology and surgical techniques. Data included demographics (age, weight, and sex) and perioperative details (operative time, estimated blood loss, moiety resected, length of hospital stay, postoperative analgesic use, complications, and need for ancillary procedures). Operative reports were reviewed for technique. Operative times were obtained from anesthesia records and included cystoscopy, retrograde pyelography, and patient repositioning when performed. General anesthesia was utilized in all procedures. Local anesthesia was utilized at incision sites for all minimally invasive techniques. An epidural was utilized for OPN patients. Complications were assessed according to the Clavien-Dindo classification system.[7] Postoperative analgesia typically included alternating Ketorolac and Acetaminophen on a scheduled regimen, with narcotics administered as needed. Analgesics were measured as mg/kg/day for data analysis and comparison. Narcotics utilized during the study period were converted to Morphine sulfate equivalents for analysis. Postoperative imaging assessment was done with ultrasound. Significant reduction in volume of the remaining moiety during follow-up was considered as atrophy. Laboratory evaluation with blood tests was not utilized. A comparison of perioperative and postoperative outcomes was performed between all 4 surgical approach groups.

Surgical Technique

Open partial nephrectomy was performed with a retroperitoneal approach. Patients were placed in the flank position and an incision was typically made below the 12th rib. The kidney was mobilized, the hilum was exposed, and the ureters were identified. The nonfunctional moiety ureter was controlled and divided. Selective ligation of the nonfunctioning vessels was performed. With the demarcation of the devascularized moiety, the partial nephrectomy was completed with cautery.

Laparoscopic partial nephrectomy began in the lithotomy position for cystoscopy and retrograde pyelography, with placement of a ureteral catheter into the renal pelvis of the healthy moiety. All procedures were performed in a transperitoneal approach with the patient in a modified flank position, 45° from horizontal. Pneumoperitoneum was achieved with the Hassan technique through the umbilicus, and insertion of a 5-mm camera port with 12-mm Hg intraabdominal target pressure. Two or three ports (3-mm or 5-mm) for instruments and retraction were utilized. Nonfunctioning moiety vasculature was selectively controlled with hemoclips or harmonic scalpel. Dissection and separation of the ureter and the partial nephrectomy were completed with the harmonic scalpel, typically following the avascular plane between the moieties.

During robotic partial nephrectomy, an 8-mm or 12-mm trocar was placed under direct vision at the umbilicus, for the endoscope. Two additional 5-mm or 8-mm robotic instruments ports were placed. An assistant port was not typically utilized. During the study period, the daVinci S and subsequently Xi were utilized. Based on surgeon preference, triangulation or midline positioning were utilized for port placement. Direct dissection of the nonfunctional moiety or retrograde dissection from the ureters was performed, based on surgeon preference. A percutaneous suture was often utilized for traction through the nonfunctional moiety, to improve exposure of the hilum. The ureter of the nonfunctioning pole was controlled and divided, with the proximal stump used to retract and expose the nonfunctional moiety. A combination of monopolar scissors, bipolar forceps, or robotic vessel sealer were used to complete the partial nephrectomy. When possible, the avascular plane between the moieties was identified and followed. The renal pelvis was opened in some cases to help define the anatomy and facilitate the extirpation.

LESS partial nephrectomy was performed using an Olympus EndoEye scope and an Olympus TriPort (Tokyo, Japan) or Applied Medical GelPOINT Mini single port device (Rancho Santa Margarita, CA). Standard 3-mm or 5-mm laparoscopic instrumentation were typically utilized. Cambridge Endo articulating instruments were used in select cases. The Olympus EndoEye is a 5-mm flexible tip laparoscope that delivers 100-degree angulation and an 85-degree field of view. The TriPort and GelPOINT Mini are multichannel single port devices that are placed via an open technique, typically through a midline umbilical incision in this series. The multichannel port was introduced. Instruments and the flexible tip laparoscope were utilized through the single port device. The dissection was similar to the other minimally invasive approaches.

Data Analysis

Continuous variables are described as medians (range). The different treatment arms were compared by the Kruksal-Wallis H test, with post hoc pairwise analysis performed when the null hypothesis of equal distribution was rejected. Categorical variables are described as frequency and percentage. Categorical variables were compared across the treatment arms with the chi-square test of independence. Multiple comparisons were adjusted by controlling the false detection rate according to the Benjamini-Hochberg method. All statistical analyses was performed on SPSS statistics v.25 (IBM, Armonk, NY) and statistical significance was set at $P < .05$.

Table 1. Patient characteristics and demographics

	OPN ($n = 24$)	LPN ($n = 7$)	RPN ($n = 18$)	LESS-PN ($n = 10$)	*P*
Median age, months (IQR)	14.5 (10.5-24.2)	11.7 (6.7-40)	43.9 (17.3-131.5)	12.9 (8.9-16.1)	.100
Median weight, kg (IQR)	11.4 (9-13.7)	9.2 (7.1-10.6)	14.4 (9.9-32.8)	9.45 (8.7-10.4)	.187
Sex (M/F)	12/12	1/6	5/13	1/9	.115
Surgery side (R/L)	13/11	1/6	8/10	5/5	.381
Resected Pole (Upper/Lower)	18/6	7/0	15/3	9/1	.487

LESS-PN, laparoendoscopic single site partial nephrectomy; LESS-PN, laparoendoscopic single site partial nephrectomy; LPN, laparoscopic partial nephrectomy; LESS-PN, laparoendoscopic single site partial nephrectomy; RPN, robotic partial nephrectomy.

RESULTS

A total of 59 pediatric patients who underwent partial nephrectomy for an upper urinary tract duplication anomaly during a 10-year period were identified and included in the study. Demographic data is presented in Table 1. Median age was 16 months (interquartile range 9-49.7). Median weight was 10.7 Kg (interquartile range 8.8-16.4). There were 19 male and 40 female patients. Forty-six percent of the removed moieties were on the right side with 83% being upper pole moieties. There were no statistically significant differences in the demographic data between the groups in terms of age, weight, sex, surgery side, or resected pole. During surgery, 81% of patients underwent cystoscopy at the beginning of the operation. Eight patients underwent a concomitant procedure during the partial nephrectomy. Five patients (2 in the open and 3 in the robotic group) were treated with Deflux injection for the ipsilateral moiety. Three additional patients underwent closure of bladder exstrophy, lower pole pyeloplasty, and umbilical hernia repair.

Perioperative data is presented in Table 2. A pairwise comparison for perioperative results was performed between each 2 groups. Median operative time for OPN (154.5 minutes, range 108-413) and LESS-PN (140 minutes, range 65-245) were found to be significantly shorter in comparison to the LPN (190 minutes, range 159-355) and RPN (256 minutes, range 163-458) approach (OPN vs LPN $P = .03$, OPN vs RPN $P = .005$, LESS-PN vs LPN $P = .02$, LESS-PN vs RPN $P = .005$). Median estimated blood loss during surgery was comparable between all minimally invasive approaches but significantly increased in the open approach (10 mL, range 0-125) to all other approaches (OPN vs LPN $P = .03$, OPN vs RPN $P = .005$, OPN vs LESS-PN $P = .03$). Intraoperative cystoscopy was performed in similar rates between the groups. There was a trend, although not significant ($P = .051$) for a decreased use of urinary catheters in the minimally invasive approaches. Less drains were used in the minimally invasive approaches in comparison to the open approach ($P = .005$). When comparing median length of hospital stay between the groups, a significantly longer hospitalization was noted for OPN (3 days, range 2-24) in comparison to all other approaches (OPN vs LPN $P = .03$, OPN vs RPN $P = .005$, OPN vs LESS-PN $P = .005$).

Postoperative analgesic use is presented in Table 3. Patients in the laparoscopic group were not treated with Ibuprofen and patients in the open group were not treated with Ketorolac due to a change in pain management practice patterns over time. After converting narcotic use to Morphine equivalents and performing a pairwise comparison between all groups, OPN required more morphine equivalents (0.554 mg/Kg/day, range 0.03-6.13) and Acetaminophen (72.12 mg/Kg/day, range 0-209.06) than all other groups in the study (Morphine: OPN vs LPN $P = .003$, OPN vs RPN $P = .005$, OPN vs LESS-PN $P = .005$; Acetaminophen: OPN vs LPN $P = .009$, OPN vs RPN $P = .035$, OPN vs LESS-PN $P = .001$).

There were no intraoperative complications noted, however, 6 patients (10.2%) had postoperative complications. All complications were Clavien-Dindo grade 2. Four patients had postoperative urinary tract infection, one patient had fever, and another patient had respiratory distress necessitating pharmacologic treatment. No patients required blood transfusion. One patient had a prolonged hospital stay due to postoperative care for bladder exstrophy closure that was performed at the same time as an OPN. Despite the long hospital stay, the narcotic use was not an isolated outlier in the OPN group, with 4 other patients who required high narcotic use. A sub analysis excluding this patient did not change the results and showed that OPN required more Morphine equivalents than the other groups. During follow-up, 8 patients have mild pelvicaliectasis in the remaining moiety, not requiring intervention. Six patients (10.2%) underwent ancillary surgical procedures. Four patients underwent lower pole Deflux injection due to low grade reflux, and 2 additional patients underwent excision of the ureteral stump. One (1.7%) patient from the LESS-PN group had atrophy of the ipsilateral moiety.

Table 2. Perioperative data

	OPN ($n = 24$)	LPN ($n = 7$)	RPN ($n = 18$)	LESS-PN ($n = 10$)	*P*
Median operative time, min (range)	154.5 (108-413)	190 (159-355)	256 (163-458)	140 (65-245)	.005
Median EBL, cc (range)	10 (0-125)	5 (0-50)	5 (0-100)	5 (0-20)	.013
Intraoperative cystoscopy (%)	79.2%	85.7%	77.8%	90%	.814
Use of drains (%)	70.8%	57.1%	22.2%	0%	.015
Urinary catheter (%)	91.7%	85.7%	77.8%	50%	.088
Median LOS, days (range)	3 (2-24)	1 (1-2)	2 (1-4)	1 (1-1)	.005

EBL, estimated blood loss; LESS-PN, laparoendoscopic single site partial nephrectomy; LOS, length of stay; LPN, laparoscopic partial nephrectomy; OPN, open partial nephrectomy; RPN, robotic partial nephrectomy.

Table 3. Postoperative analgesic use

	OPN ($n = 24$)	LPN ($n = 7$)	RPN ($n = 18$)	LESS-PN ($n = 10$)	P
Median Ibuprofen mg/kg/day (range)	0.5 (0-60)	0	0.3 (0-41.88)	0.1 (0-10.24)	.186
Median Acetaminophen mg/kg/day (range)	72.12 (0-209.06)	35.78 (30-47.76)	43.90 (19.90-195.46)	34.96 (20-45.18)	.004
Median Ketorolac mg/kg/day (range)	0	0.50 (0-1.53)	0.52 (0-2.53)	1.01 (0-1.53)	.005
Median Morphine equivalents mg/kg/day (range)	0.554 (0.03-6.13)	0.015 (0-0.07)	0.039 (0-0.42)	0	.005

LESS-PN, laparoendoscopic single site partial nephrectomy; LPN, laparoscopic partial nephrectomy; OPN,open partial nephrectomy; RPN, robotic partial nephrectomy.

DISCUSSION

An upper urinary tract duplication anomaly occurs in approximately 1% of the population. Children with duplication anomalies are prone to significant morbidity, including recurrent infections, loss of renal function, or incontinence.[8] Surgical treatment is advocated for symptomatic moieties. Since the early descriptions of open partial nephrectomy for duplication anomalies,[9,10] minimally invasive approaches have gained popularity and are considered by some to be the gold standard for treatment in these conditions. Pediatric laparoscopic partial nephrectomy for a nonfunctioning moiety, first described in 1993[2] has paved the way for a larger armamentarium of surgical techniques existing today and offering less morbidity and potential for better cosmesis. Robotic partial nephrectomy has demonstrated advantages such as enhanced dexterity, less blood transfusions, shorter hospitalization, and reduced postoperative pain.[11,12] LapaRoEndoscopic Single Site surgery has been recently implemented in the pediatric population[3,13] and has provided the possibility of a single skin and fascial incision readily hidden in the umbilicus, providing the potential for excellent cosmesis.

Only few studies have compared different surgical approaches for the treatment of a nonfunctioning moiety in a duplicated system. Golebiewski et al[14] described their experience in comparing 12 pediatric patients who underwent open upper pole partial nephrectomy with 15 patients who were operated in the laparoscopic approach. In their study, there was no statistically significant difference in operating time between the 2 groups (mean of 148 minutes [range 100-220] in laparoscopy vs 124 minutes [range 100-150] in open surgery), however, in the open approach, mean hospital stay ($P = .048$) was longer and analgesic requirements ($P = .005$) were significantly increased.

In a retrospective multicenter analysis, Ballouhey et al[15] compared 15 patients who underwent robotic heminephrectomy, and 13 patients who underwent open retroperitoneal heminephrectomy. Mean hospital stay was significantly longer in the open group (6.3 days, range 5-8 days vs 3.4 days, range 1-7 days; $P < .001$). When comparing postoperative pain control, total morphine equivalent intake was significantly greater in the open group (0.52 mg/kg/day vs 1.08 mg/kg/day; $P < .001$). There was no significant difference in terms of operating time, complication rate, or renal outcomes.

Esposito et al[16] published an international multicenter European study analyzing data from 102 pediatric patients who underwent partial nephrectomy in a 5-year period using 2 different laparoscopic approaches. Fifty-two children underwent transperitoneal laparoscopic partial nephrectomy and 50 children underwent retroperitoneoscopic partial nephrectomy. The overall complications rate was significantly higher after retroperitoneoscopic (15/50, 30%) than laparoscopic (10/52, 19%) ($P = .05$). In both groups, no conversion to open surgery was reported. Mean operative time (LPN- 166.2 minutes vs RPN- 255 minutes; $P < .001$) and mean length of stay (LPN- 3.5 days vs RPN- 4.1 days; $P < .001$) were significantly shorter in the transperitoneal laparoscopic group. No postoperative loss of renal function was reported in the groups.

In terms of perioperative results of our study, several advantages in favor of the minimally invasive approaches may be suggested. When compared to the open approach, we found all 3 minimally invasive techniques (LPN, RPN, and LESS-PN) were associated with less estimated blood loss during surgery, decreased usage of drains and catheters, and a shorter hospitalization. Operating time did show an advantage in OPN in comparison to LPN or RPN, but not in comparison to LESS-PN. When comparing between the different minimally invasive techniques, LESS-PN was associated with shorter operating time in comparison to LPN or RPN. All other parameters did not show any significant advantage to one approach over the other.

Although differences in several parameters such as the use of drains, catheters and length of hospitalization can be attributed to specific surgeon's preference, it is our belief that in most cases they reflect a response to a more difficult or complicated surgical case. Despite a significant difference in estimated blood loss between open and minimally invasive surgery, overall blood loss was relatively low and one might question the clinical relevance of this outcome. Since estimated blood loss was not considered minimal in several patients in all groups, the physiology of

blood loss in the pediatric population and the nature of partial nephrectomy, we consider estimated blood loss to be an important parameter in this study.

An analysis of postoperative pain management demonstrated a clear advantage to all minimally invasive approaches over OPN. Although there were slight variations in pain management protocols over a 10-year period, our data show that the open approach is associated with increased usage of narcotics and Acetaminophen.

A non-narcotic pathway (NNP) for postoperative analgesia after pediatric minimally invasive surgery was previously described by Lee et al.[17] In this retrospective analysis, 96 pediatric patients underwent robotic assisted pyeloplasty. Children managed in a NNP received alternating doses of scheduled intravenous acetaminophen and ketorolac every 3 hours throughout the postoperative course. Forty-nine (51.0%) patients were managed with NNP, and 47 (49.0%) patients were managed with a combination of NSAID and narcotics according to a visual analog scale pain management regime. A larger proportion of patients in the NNP did not receive postoperative narcotic medications (71.4% vs 25.5%; $P < .001$). Patients in the NNP were administered less narcotics (median 0.000 mg vs 0.041 mg morphine equivalents/kg/day; $P < .001$) and had a shorter length of stay (median 1.0 day vs 2.0 days; $P < .001$). There was no significant difference in the proportion of patients with postoperative complications ($P = .958$) or surgical success ($P = .958$). They concluded that a NNP for postoperative pain management is a viable and effective analgesic regimen and may facilitate a shorter hospital stay. The majority of patients managed with this pathway had adequate pain control without being subject to the potential adverse effects of narcotic medications. In our study, the NNP was utilized in all 10 patients who underwent LESS-PN and was shown to be effective. An increase trend for usage of Ketorolac in this group was noted but did not reach statistical significance. There was no increased use of Acetaminophen or Ibuprofen in comparison to all other groups.

The results of our study demonstrate the safety and efficacy of the minimally invasive approach for pediatric partial nephrectomy. We believe advantages such as decreased postoperative pain and analgesia requirements, shorter hospital stay, less blood loss, and better cosmetic results support the preference of the minimally invasive approach over open surgery in these cases. Increase in operating times in RPN and LPN may be mitigated by experienced staff in the operating room. As cost analysis was not in the scope of our study, comparative data were not examined, but it is our belief that increasing use of minimally invasive surgery, as was shown in previous studies, can translate into a cost reduction.[18] This should be examined further particularly for pediatric robotic surgery.

The limitations of our study include its retrospective nature, small sample size in each group, lack of comparative cost analysis, and the fact that all minimal invasive surgeries were performed in 2 specialized medical centers by a small number of surgeons. These facts can limit the generalization of our findings. We do not routinely perform nuclear renal scan after partial nephrectomy regardless of the surgical approach, thus data regarding residual function of the remaining moiety is not available.

To the best of our knowledge, this is the first study to compare 4 different surgical techniques in performing pediatric partial nephrectomy for upper urinary tract duplication anomalies.

CONCLUSION

Minimally invasive approaches (LPN, RPN, and LESS-PN) for partial nephrectomy in upper urinary tract duplication anomalies may be associated with decreased postoperative analgesia requirements, shorter hospital stay, less blood loss, and less use of drains in comparison to the open approach, while demonstrating efficacy and safety. LESS-PN was associated with shorter operative time in comparison to laparoscopic or robotic surgery. There were no other significant differences between all minimally invasive approaches.

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References

1. Koyanagi T, Tsuji I. Experience of complete duplication of the collecting system: retrospective analysis of 23 cases with particular emphasis on the type of ureteral hiatus and its implication in the management of duplex. *Int Urol Nephrol.* 1979;11:27–38.
2. Jordan GH, Winslow BH. Laparoendoscopic upper pole partial nephrectomy with ureterectomy. *J Urol.* 1993;150:940–943.
3. Bansal D, Cost NG, Bean CM, Minevich EA, Noh PH. Pediatric urological laparoendoscopic single site surgery: single surgeon experience. *J Pediatr Urol.* 2014;10:1170–1175.
4. Herz D, Smith J, McLeod D, Schober M, Preece J, Merguerian P. Robot-assisted laparoscopic management of duplex renal anomaly: comparison of surgical outcomes to traditional pure laparoscopic and open surgery. *J Pediatr Urol.* 2016;12. 44 e1-7.
5. Romao RL, Figueroa V, Salle JL, Koyle MA, Bagli DJ, Lorenzo AJ. Laparoscopic ureteral ligation (clipping): a novel, simple procedure for pediatric urinary incontinence due to ectopic ureters associated with non-functioning upper pole renal moieties. *J Pediatr Urol.* 2014;10:1089–1094.
6. Prieto J, Ziada A, Baker L, Snodgrass W. Ureteroureterostomy via inguinal incision for ectopic ureters and ureteroceles without ipsilateral lower pole reflux. *J Urol.* 2009;181:1844–1848. discussion 8-50.
7. Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg.* 2004;240:205–213.
8. Bolduc S, Upadhyay J, Sherman C, et al. Histology of upper pole is unaffected by prenatal diagnosis in duplex system ureteroceles. *J Urol.* 2002;168:1123–1126.
9. Belman AB, Filmer RB, King LR. Surgical management of duplication of the collecting system. *J Urol.* 1974;112:316–321.
10. Culp OS. Heminephro-ureterectomy: comparison of one-stage and two-stage operations. *J Urol.* 1960;83:369–375.
11. Choi JE, You JH, Kim DK, Rha KH, Lee SH. Comparison of perioperative outcomes between robotic and laparoscopic partial nephrectomy: a systematic review and meta-analysis. *Eur Urol.* 2015;67:891–901.
12. Wu Z, Li M, Liu B, et al. Robotic versus open partial nephrectomy: a systematic review and meta-analysis. *PloS One.* 2014;9:e94878.

13. Kaouk JH, Palmer JS. Single-port laparoscopic surgery: initial experience in children for varicocelectomy. *BJU Int*. 2008;102:97–99.
14. Golebiewski A, Losin M, Murawski M, Komasara L, Czauderna P. Laparoscopic versus open upper pole heminephroureterectomy for the treatment of duplex kidneys in children. *J Laparoendoscopic Adv Surg Tech Part A*. 2013;23:942–945.
15. Ballouhey Q, Binet A, Clermidi P, et al. Partial nephrectomy for small children: robot-assisted versus open surgery. *Int J Urol*. 2017;24:855–860.
16. Esposito C, Escolino M, Miyano G, et al. A comparison between laparoscopic and retroperitoneoscopic approach for partial nephrectomy in children with duplex kidney: a multicentric survey. *World J Urol*. 2016;34:939–948.
17. Lee Z, Schulte M, DeFoor WR, et al. A Non-Narcotic Pathway for the Management of Postoperative pain following pediatric robotic pyeloplasty. *J Endourol*. 2017;31:255–258.
18. Liberman D, Trinh QD, Jeldres C, Zorn KC. Is robotic surgery cost-effective: yes. *Curr Opin Urol*. 2012;22:61–65.