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A standardized technique of laparoscopic placement of peritoneal dialysis catheter with omentectomy and closure of patent processus vaginalis: A 3-in-1 minimally invasive surgical approach in children☆,☆☆

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ABSTRACT

Background: Omental wrapping is a common cause for catheter failure in children on peritoneal dialysis (PD). Previous studies are conflicting in the benefits of omentectomy.
Methods: We conducted a retrospective study comparing children who underwent PD catheter placement by a standardized laparoscopic three-in-one technique (lap3-in-1) from 2013 to 2018 versus a historical control cohort by open surgery without omentectomy. Lap3-in-1technique combined catheter placement with well-defined indication and extent of omentectomy, and closure of any patent processus vaginalis (PPV).
Results: There were 33 and 32 children in the lap3-in-1 and control cohorts respectively. 4/33(12.1%) in lap3-in-1 had reoperations for catheter failures which equated 1 reoperation per 144 catheter months. No reoperations were performed in lap3-in-1 cohort for omental wrapping or inguinal hernia, compared with 13/32 (41%; $p < 0.001$) and 5/32 (16%; $p = 0.02$) in the control cohort. Kaplan Meier survival curves showed significantly longer catheter life in the lap3-in-1 cohort ($p < 0.001$). In multivariate analysis by the COX proportional hazards model, the lap3-in-1 approach had significantly reduced risk of reoperation for catheter failure (HR 0.11; 95% CI: 0.04–0.31; $p < 0.001$).
Conclusions: The lap3-in-1 technique is effective in selecting those children who would benefit from omentectomy, and avoiding a second operation for inguinal hernia which develops after PD.
Level of evidence: Treatment study, level III

Peritoneal dialysis (PD) is the preferred option for children requiring renal replacement therapy, and can be applied in hemodynamically unstable patients across all age groups. PD does not require vascular access and anticoagulation [1]. In contrast to acute renal failure, children with chronic renal failure are in general dependent on PD for a longer period to be bridged to the definitive treatment by renal transplant. While the operative procedure for the placement of PD catheter is not technically demanding, 39–49% reoperation rates owing to catheter failure were reported in the published literature [2–4]. PD catheter malfunction and catheter-related infective complications are the two most common causes of catheter failure resulting in reoperation [2–5].

Catheter wrapping by omentum is a common reason for PD catheter malfunction. It is unlikely for the omental wrap to resolve with conservative management [6]. Previous studies have investigated the performance of omentectomy at the time of PD catheter placement to reduce the incidence of catheter malfunction, and conflicting results were reported in the literature [2–5,7,8]. A lack of standardization concerning the indication and technique of omentectomy limits the strengths of the evidence in the existing literature [3]. There is no consensus as to what extent omentectomy is considered to be adequate. Repeating omentectomy has been reported for recurrent omental wrapping [3,5].

Another complication requiring a second operation is the inguinal hernia development after the commencement of PD [2,8]. It happens following the increased intraabdominal pressure by the dialysate in the presence of a patent processus vaginalis (PPV), which has been asymptomatic and has not been known before PD. To address the high reoperation rate related to PD catheter, we introduced in 2013 a standardized protocol of laparoscopic placement of PD catheter, coupled

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with a well-defined indication for omentectomy and its extent, as well as closure of PPV when present. In this study we sought to investigate the outcomes of this laparoscopic three-in-one (lap3-in-1) approach.

1. Methods

1.1. Patient selection: lap3-in-1 cohort

We performed a retrospective review of the medical records of all consecutive children aged less than 18 years suffering from chronic renal failure who underwent PD catheter placement by the lap3-in-1 approach during the study period of May 2013 to Nov 2018. Study subjects included patients who had PD catheter placement for their first time and others who had undergone PD catheter placement previously by other surgical methods. We excluded those patients who had a previous history of omentectomy or inguinal hernia repair prior to the lap3-in-1 PD catheter placement. The lap3-in-1 PD catheter placement was performed by a group of 3 pediatric surgeons while the PD was managed by a single pediatric nephrology group.

1.2. Control cohort

For comparison in this study, a historical control cohort was identified, which included consecutive new patients aged less than 18 years who were referred to the same pediatric nephrology group for the management of PD from 2008 to 2014. Patients in the control cohort had their first PD catheter placement by open surgery without omentectomy at outside institutions by another group of surgeons. The operative records were available for review. Only the data of the first PD catheter placement were included for comparative analysis. None of the patients in the control cohort had prior surgery for inguinal hernia. The same type of double-cuffed straight Tenckhoff catheters was used in both the lap3-in-1 and control cohort. The catheters were provided by the single pediatric nephrology group.

1.3. Surgical techniques: PD catheter placement, indication and extent of omentectomy, PPV closure

The procedure started with diagnostic laparoscopy by a 5-mm telescope at the umbilical port. Any PPVs, unilateral or bilateral, were closed laparoscopically using the hook technique, which we reported previously [9] and has been our standard technique for pediatric inguinal hernia repair for over a decade. Two stab incisions were made at the midline of the lower abdomen and over the deep ring region for the trocarless passage of 3-mm graspers and the hernia hook, respectively. The hernia hook dissected around the deep inguinal ring to place the suture that encircled the deep ring extraperitoneally. The suture included the round ligament in girls while remaining superficial to testicular vessels and vas deferens in boys. The suture was tied extracorporeally to close the PPV.

Any omentum that extended below umbilicus was removed laparoscopically. When omentectomy was indicated, one or two additional 5-mm ports were placed at the right iliac fossa. Only one 5-mm port might sometimes be enough if a trocarless 3-mm grasper had already been placed for PPV closure. A 5-mm ultrasonic energy source was used to excise all omental tissues that extended below the umbilicus. The telescope was moved to the right iliac fossa port during omentectomy. Thin omentum was retrieved through the umbilical port site. Thick omentum was placed in an endobag delivered through a 10-mm port, which was upsized from the 5-mm umbilical port. The omentum contained in the endobag was then removed in piecemeal at the umbilical port site while avoiding excessive enlargement of the fascial defect.

A straight double-cuffed Tenckhoff catheter was inserted through the umbilical port site with double purse-string sutures placed around its entry at the peritoneum and fascial defect to avoid leakage. One of the suture ends of the purse-string got around and tied onto the cuff to prevent the creation of abnormal torque at the cuff, which might shift the catheter tip upward and out of the pelvis. The distal tip of the catheter was placed behind the urinary bladder by graspers under laparoscopic guidance. A subcutaneous tunnel was created and the catheter exited laterally at the right upper quadrant. (Fig. 1).

1.4. Data collection and primary outcomes

Data collected included patients' demographics of gender and age at the time of surgery, surgical approach, intraoperative complications, postoperative catheter-related complications, reoperations, catheter life and inguinal hernia development after PD commencement. Primary outcomes evaluated were reoperation for catheter failure and inguinal hernia after PD. Reasons for catheter failure were defined by the indications for reoperation. In case catheter malfunction was the indication for reoperation, the cause of malfunction was defined by the operative findings during the reoperation. Reoperation included both catheter replacement surgery and salvage surgery without removing the catheter. Catheter life was defined by the time interval from catheter placement to i) reoperation for catheter failure, or ii) removal for completion of PD, or iii) the latest follow-up if the catheter was still in use.

1.5. Statistical analysis

Categorical data were reported in percentage as frequency. Nonparametric continuous data were reported as median with range. The two cohorts were compared in the univariate analysis by chi-square and Fisher's exact test for categorical data, and by Mann Whitney test for continuous data. Kaplan Meier survival curve was used to analyze the catheter life with the time to event defined by the time interval from catheter placement to reoperation for catheter failure. Catheter removal owing to completion of PD treatment after renal transplant or switching to hemodialysis and those PD catheters remaining in use at the time of data collection were considered to be censored data. The catheter survival curves of the two cohorts were compared in a univariate analysis by log-rank test. The COX proportional hazards model was used in multivariate analysis to investigate the independent effect of potential variables in association with reoperation for catheter failure. Hazard ratio (HR) was reported with 95% confidence intervals (95% CI). P-values less than 0.05 were considered to be significant.

The study protocol was approved by the clinical research ethical committee of our institution.

2. Results

There were 33 and 32 children in the lap3-in-1 and control cohorts, respectively. There was no difference between the two cohorts in gender ($p = 0.91$) and median age at the time of surgery ($p = 0.90$). 24/33 of the lap3-in-1 cohort had their first PD catheter placement while 9 others had a prior history of PD catheter placement without omentectomy by other surgical techniques. All 32 children in the control cohort had their first PD catheter placement by open surgery without omentectomy.

24/33(73%) in the lap3-in-1 cohort underwent laparoscopic omentectomy according to the indication of the protocol, and 14/33 (42%) had either unilateral or bilateral PPV closure (unilateral = 8; bilateral = 6). There was no conversion to open surgery and no intraoperative complications in the lap3-in-1 cohort.

Thirty-three patients of the lap3-in-1 cohort had a total of 577 catheter-months. Twelve (36.4%) were bridged to completion of PD by renal transplant after single catheter placement by lap3-in-1 technique, 1 (3%) switched to hemodialysis, 16 (48.5%) still had ongoing PD with their catheters functioning normally at the time of data collection, 4

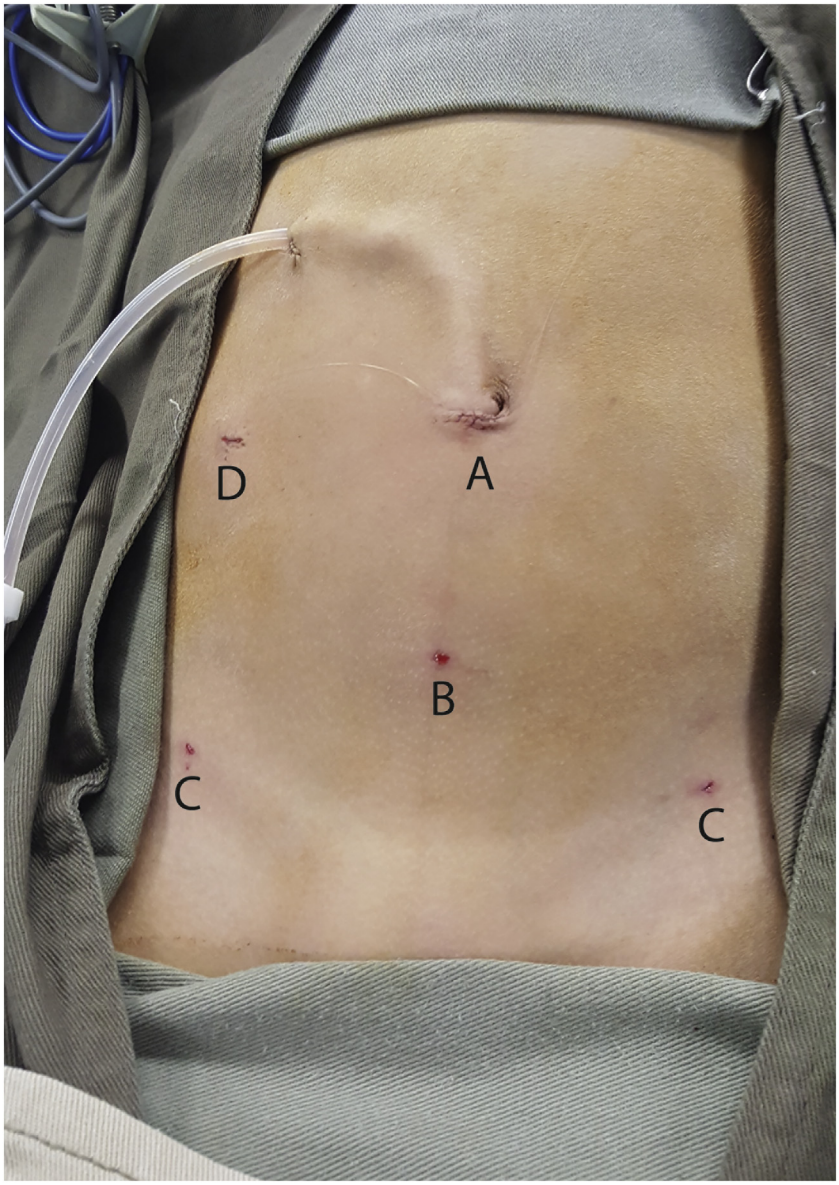


Fig. 1. At the end of the lap3-in-1 procedure of PD catheter placement, omentectomy and bilateral PPV closure. A = umbilical port site and entry site of PD catheter into peritoneal cavity. B = stab wound for trocarless insertion of 3-mm graspers. C = bilateral stab wounds for passage of hernia hook. D = additional 5-mm working port site.

(12.1%) had reoperations for catheter failures, which equaled 1 reoperation per 144 catheter-months.

Table 1 showed the comparisons of the two cohorts. The median catheter life of the lap3-in-1 was significantly longer than that of the control cohort ($p < 0.001$). The overall reoperation rate for catheter failure in the lap3-in-1 cohort was significantly lower than that of control ($p < 0.001$). Of the 4 patients in lap3-in-1 cohort requiring reoperation, 2 had catheter tip migration and the other 2 had refractory infective complications. No patients in the lap3-in-1 cohort had omental blockage compared with 13/32 (41%) in the control cohort who had omental wrapping confirmed during reoperations ($p < 0.001$).

There was no difference between the two cohorts in the incidence of catheter tip migration ($p = 0.37$) and in the crude incidence rates of catheter-related infective complications ($p = 0.48$).

None of the patients in the lap3-in-1 cohort developed inguinal hernia compared with 5/32(16%) in the control cohort ($p = 0.02$). These 5 patients underwent a second operation of inguinal herniotomy at 2 to 24 months after the commencement of PD.

The Kaplan Meier survival curves showed significantly longer catheter life in the lap3-in-1 than the control cohort ($p < 0.001$) (Fig. 2). In a multivariate analysis by the COX proportional hazards model, covariates entered into the model included gender, age, surgical approach and the crude incidence of infective complications. After adjusting for other potential variables, the lap3-in-1 approach was significantly associated with a reduced risk of reoperation for catheter failure (HR 0.11; 95% CI: 0.04–0.31; $p < 0.001$).

3. Discussion

Our findings suggest that the lap3-in-1 technique reduces the risk of catheter failure, thus prolonging the PD catheter life. Such an advantage is particularly relevant to children with chronic renal failure who are dependent on renal replacement therapy until they are bridged to renal transplant, which may take years. In a previous study on 81 children on PD for chronic renal failure, Cribbs et al. noted that 32% of patients had 2–5 catheter placements within a 6-year study period [5]. Our result of 1 reoperation for catheter failure per 144 catheter-months by lap3-in-1 technique compares favorably with previous reports of 1 reoperation per 34 and 41 catheter-months [2,4].

Table 1
Univariate comparison between the lap3-in-1 cohort and control cohort.

	lap3-in-1 N = 33(%)	Control N = 32(%)	p-values
Gender: male/female	18/15	17/15	0.91
Median age at the time of surgery (years)	10 range 1–17 years	10.5 range 1 month–17 years	0.81
Omentectomy at PD catheter placement	24/33(72.7)	0/32	NA
PPV closure at PD catheter placement	14/33(42.4) Left = 5; Right = 3; Bilateral = 6	0/32	NA
Overall reoperation rates owing to catheter failure	4/33(12.1)	23/32(71.9)	<**0.001**
I) Omental block	0/33	13/32(40.6)	<**0.001**
II) Catheter tip displacement	2/33(6.1)	4/32(12.5)	0.37
III) Refractory tunnel infection/peritonitis	2/33(6.1)	6/32(18.8)	0.12
Median catheter life (months)	15 range 1–44 months	4 range 1 week to 84 months	<**0.001**
Inguinal hernia after PD	0/33	5/32(15.6)	**0.02**
Crude incidence rates of infective complications	12/33(36.4)	9/32(28.1)	0.48

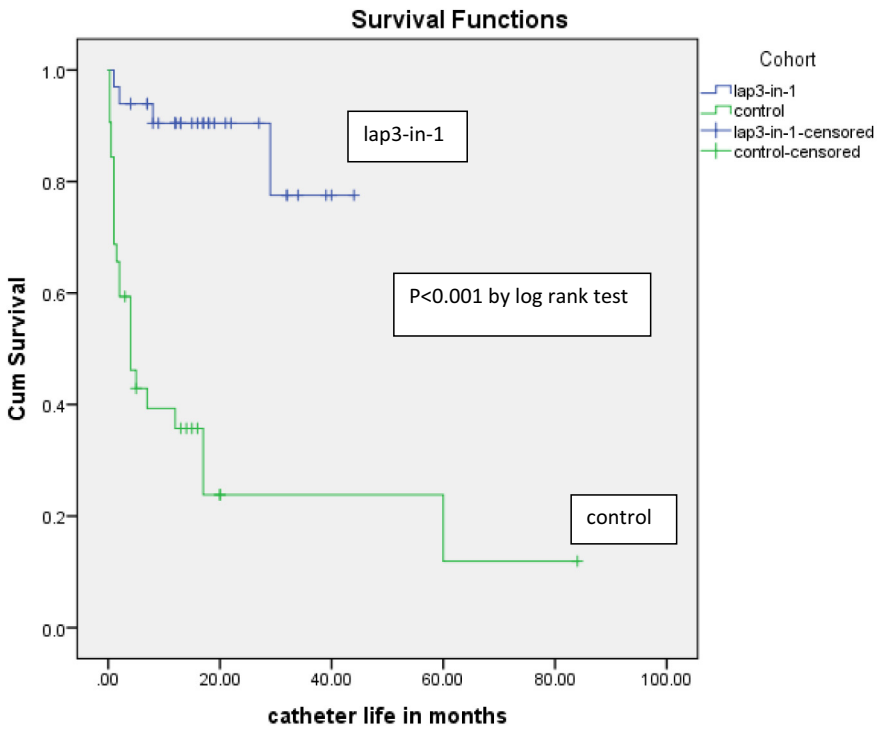
PD = peritoneal dialysis; PPV = patent processus vaginalis; NA = not applicable as no omentectomy/PPV closure being the inclusion criteria of the control.

Catheter obstruction by omental wrapping is a common reason for catheter failure, and recent literature has reported catheter obstruction rates of 26 to 36% [3,6,10]. Performing omentectomy at the time of PD catheter placement has been suggested by some investigators [2,3,5,8] but not the others [4,7,11]. Current evidence in published literature is short of the strength to make recommendations [10]. A lack of standardization concerning the indication and technical thoroughness of omentectomy divided opinions within the same institution, leading to inconsistent decisions among the surgeons; these were all limitations described in previous studies [2,3,5].

Omentectomy is usually described as partial, whether it is performed in open surgery [7,10] or by laparoscopy when the omentum is exteriorized through a port site for extracorporeal resection [4,12,13]. Recurrent omental wrapping requiring repeat omentectomy has been well-recognized after partial omentectomy [3,5,11]. There is no universally agreed definition of "complete" or "adequate" omentectomy.

Our study is unique among others of its kind given that we investigated a standardized technique of performing laparoscopic omentectomy with a well-defined indication. We remove any omentum that extends below the umbilicus totally by laparoscopic means to ensure its thoroughness. The omentum has both vertical and transverse dimensions. While completeness of omentectomy may possibly be defined along the transverse axis of omentum, leaving behind a short safety margin of omental tissue at its vertical axis is necessary to avoid thermal injury that can be caused by the laparoscopic energy source to the transverse colon and the gastroepiploic arcade along the stomach greater curvature. The lap3-in-1 approach makes sense in the extent of omentectomy as the catheter is inserted at the umbilical level.

We remain adamant that thick redundant omentum should be placed in an endobag before retrieval to prevent leaving in the peritoneal cavity any broken fragments that may block the catheter. Another advantage of using the endobag is the feasibility of removing the fatty



Cum = cumulative

Fig. 2. Kaplan Meier survival curves comparing catheter life of lap3-in-1 cohort versus control cohort. Cum = cumulative.

tissue in piecemeal so that the fascial defect does not need to be enlarged excessively to reduce the risk of dialysate fluid leak and incisional hernia. Using the lap3-in-1 protocol, 73% of our patients required omentectomy. None of our patients, whether they had omentectomy or not, developed catheter failure by omental wrapping.

In this study we compared our lap3-in-1 technique with a historical cohort by open surgery without omentectomy. Our findings should not be oversimplified or misinterpreted as evidence of the superiority of laparoscopy over open surgery in PD catheter placement. Without clearly defining when and how omentectomy should be performed, we tend to agree with others that laparoscopic PD catheter placement itself may not have any advantage over open surgery in reducing catheter failure rates [2,5,8]. One of the merits of laparoscopy is its excellent visualization of the whole omentum inside the abdomen, which makes the standardization possible with respect to the indication and extent of omentectomy. Attempting such standardization would be difficult if only a part of the omentum is delivered through an open wound or a port site. By standardizing the indication for selective omentectomy and its extent, the reoperation rate for catheter failure after the lap3-in-1 technique was 12.1%. Our result compares favorably with previous studies which reported 15–19% reoperation rates after performing non-standardized omentectomy routinely [3,5,10].

Of the 2 patients in the lap3-in-1 cohort who required reoperation owing to catheter tip migration, we noted abnormal torque at the cuff above the fascial defect during the reoperation. We subsequently modified the technique by having the pursestring suture tied around the distal cuff to stabilize it above the fascia. We have not encountered any catheter tip upward migration since then.

Asymptomatic PPV was detected in 42% of the patients in the lap3-in-1 cohort. The prevalence rate appears to be comparable to that of the asymptomatic contralateral PPV among our local children who present with unilateral inguinal hernias [14]. Our finding that 16% of the patients in the control cohort developed symptomatic inguinal hernia within 2 years after PD commencement is in agreement with previous reports [2,8]. A more serious complication of PD catheter tip being migrated into an inguinal hernia sac of a child has recently been reported [15].

Not all asymptomatic PPVs will develop into a symptomatic inguinal hernia, but an increase in intraabdominal pressure such as PD can be a predisposing factor. It was estimated in a recent study that 21 asymptomatic PPVs need to be closed prophylactically to prevent the occurrence of one metachronous inguinal hernia in those children who present with unilateral inguinal hernia [16] This is in contrast to the present study that asymptomatic PPV was detected in 42% children in the lap3-in-1 cohort while 16% in the control cohort developed inguinal hernia after PD. Based on these findings, prophylactic closure of asymptomatic PPVs in 3 pediatric patients who need PD may avoid a second surgery in 1 patient for inguinal hernia development after PD. Our findings, however, need to be interpreted with caution given the small sample size. Nevertheless, the present study provides further support to the hypothesis that increased intraabdominal pressure by the dialysate would increase the incidence of turning an asymptomatic PPV to a symptomatic inguinal hernia.

It is difficult to predict which PPV will and which will not develop into symptomatic inguinal hernia after PD based on the laparoscopic appearance. It remains our current practice to close all PPVs prophylactically at the time of PD catheter placement provided that informed consent is obtained from parents who understand and accept the small risk. Dreuning et al. in the recent meta-analysis did not identify any reports on testicular atrophy or injury to vas deferens in the laparoscopic groups of previous randomized controlled trials comparing laparoscopic versus open inguinal hernia repair in children [17]. Using a national database of 75,486 pediatric patients who underwent inguinal hernia repair by either laparoscopic or open method, Fujiogi et al. reported a 0.3% complication rate associated with laparoscopic repair [18]. The authors found that overall only 1 and 6 patients had injury to ovary and vas deferens, respectively [18].

We acknowledge the limitations intrinsic to the retrospective nature of our study in a single institution. There was no randomization. The patients of the control cohort underwent catheter placement at outside institutions where the operating surgeons might vary in their experience and techniques even though all the procedures were open surgery without omentectomy. The collinearity effect of laparoscopy and selective omentectomy of the lap3-in-1 cohort do not allow our study to separately compare laparoscopy versus open, or omentectomy versus no omentectomy. The nature of the control cohort makes difficult interpretation of our results for any possible advantages of the lap3-in-1 technique over the common practice of performing partial omentectomy routinely during PD catheter placement. Generalizability of our technique may be restricted to those who adopt laparoscopic hernia repairs in their usual practice.

The lap3-in-1 technique combines PD catheter placement, omentectomy and PPV closure into a single laparoscopic surgery, which promotes catheter longevity. The approach allows accurate selection of patients who would benefit from omentectomy, ascertains the thoroughness of omentectomy when indicated, and prevents subsequent development of an inguinal hernia.

Conflicts of interest disclosure

All of the authors have no competing interest to declare.

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References

[1] White CT, Gowrishankar M, Feber J, et al. Canadian Association of Pediatric Nephrologists (CAPN); Peritoneal Dialysis Working Group. Clinical practice guidelines for pediatric peritoneal dialysis. Pediatr Nephrol 2006 Aug;21(8):1059–66.
[2] Phan J, Stanford S, Zaritsky JJ, et al. Risk factors for morbidity and mortality in pediatric patients with peritoneal dialysis catheters. J Pediatr Surg 2013 Jan;48(1):197–202.
[3] Ladd AP, Breckler FD, Novotny NM. Impact of primary omentectomy on longevity of peritoneal dialysis catheters in children. Am J Surg 2011 Mar;201(3):401–4 discussion 404-5.
[4] Carpenter JL, Fallon SC, Swartz SJ, et al. Outcomes after peritoneal dialysis catheter placement. J Pediatr Surg 2016 May;51(5):730–3.
[5] Cribbs RK, Greenbaum LA, Heiss KF. Risk factors for early peritoneal dialysis catheter failure in children. J Pediatr Surg 2010 Mar;45(3):585–9.
[6] Esposito F, Di Serafino M, Ambrosio C, et al. Chronic peritoneal dialysis in children: the role of ultrasound in the diagnosis of peritoneal catheter obstruction. J Ultrasound 2016 May 25;19(3):191–6.
[7] Radtke J, Schild R, Reismann M, et al. Obstruction of peritoneal dialysis catheter is associated with catheter type and independent of omentectomy: a comparative data analysis from a transplant surgical and a pediatric surgical department. J Pediatr Surg 2018 Apr;53(4):640–3.
[8] LaPlant MB, Saltzman DA, Segura BJ, et al. Peritoneal dialysis catheter placement, outcomes and complications. Pediatr Surg Int 2018 Nov;34(11):1239–44.
[9] Tam YH, Lee KH, Sihoe JD, et al. Laparoscopic hernia repair in children by the hook method: a single-center series of 433 consecutive patients. J Pediatr Surg 2009 Aug;44(8):1502–5.
[10] Lemoine C, Keswani M, Superina R. Factors associated with early peritoneal dialysis catheter malfunction. J Pediatr Surg 2019;54(5):1069–75.
[11] Stewart CL, Acker SN, Pyle LL, et al. Factors associated with peritoneal dialysis catheter complications in children. J Pediatr Surg 2016 Jan;51(1):159–62.
[12] Numanoglu A, Rasche L, Roth MA, et al. Laparoscopic insertion with tip suturing, omentectomy, and ovariopexy improves lifespan of peritoneal dialysis catheters in children. J Laparoendosc Adv Surg Tech A 2008 Apr;18(2):302–5.
[13] Stringel G, McBride W, Weiss R. Laparoscopic placement of peritoneal dialysis catheters in children. J Pediatr Surg 2008 May;43(5):857–60.
[14] Tam YH, Wong YS, Chan KW, et al. Simple maneuvers to reduce the incidence of false-negative findings for contralateral patent processus vaginalis during laparoscopic hernia repair in children: a comparative study between 2 cohorts. J Pediatr Surg 2013 Apr;48(4):826–9.
[15] Teoh CW, Haydar R, Gillick J, et al. Migration of Tenckhoff catheter into an occult inguinal hernia. Perit Dial Int 2015 Jan-Feb;35(1):113–4.

[16] Zhao J, Chen Y, Lin J, et al. Potential value of routine contralateral patent processus vaginalis repair in children with unilateral inguinal hernia. Br J Surg 2017 Jan;104(1):148–51.
[17] Dreuning K, Maat S, Twisk J, van Heurn E, Derikx J. Laparoscopic versus open pediatric inguinal hernia repair: state-of-the-art comparison and future perspectives from a meta-analysis. Surg Endosc. 2019 Jul 17. doi: https://doi.org/10.1007/s00464-019-06960-2. [Epub ahead of print]
[18] Fujiogi M, Michihata N, Matsui H, et al. Outcomes following laparoscopic versus open surgery for pediatric inguinal hernia repair: Analysis using a national inpatient database in Japan. J Pediatr Surg 2019 Mar;54(3):577–81.