Clinical Research

Laparoscopic Tenckhoff catheter insertion technique with Alken telescopic metal dilator in pediatric population

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ABSTRACT

BACKGROUND End-stage renal disease (ESRD) is a major public health concern worldwide, with peritoneal dialysis (PD) offering a key alternative to hemodialysis. Flow restriction due to catheter migration is a common complication, affecting 7–26% of patients with PD. This study aimed to reduce complications in pediatric patients by examining a novel laparoscopic Tenckhoff catheter insertion technique using an Alken telescopic metal dilator.

METHODS In a prospective observational study conducted between September 2018 and October 2022, 33 pediatric patients with ESRD underwent laparoscopic Tenckhoff catheter insertion using a combination of laparoscopic and Seldinger techniques with Alken dilators. This approach involves rectus sheath tunneling using a nephrostomy puncture needle, wire insertion, and dilatation of up to 15 Fr using Alken telescopic metal dilators under laparoscopic guidance. Survival analysis was used to assess catheter survival and complication rates.

RESULTS The mean (standard deviation [SD]) patient age was 11.92 (3.7) years, with a median follow-up of 21.3 months. Catheter survival was 84.8%, with 5 catheter withdrawals due to infections (4 cases) or obstruction (1 case). Early and late complications, including exit-site infection, peritonitis, and catheter obstruction, occurred annually at rates of 0.10, 0.03, and 0.02 episodes per patient, respectively. No pericatheter leakage occurred.

CONCLUSIONS This novel laparoscopic Tenckhoff catheter insertion technique using an Alken telescopic metal dilator become a simple and minimally invasive method, and associated with high catheter survival and low complication rates. Therefore, further comparative studies are recommended.

KEYWORDS end-stage renal disease, laparoscopy, pediatrics, peritoneal dialysis, surgical procedures

Chronic kidney disease (CKD) in children is a significant public health concern. Previous studies have estimated the prevalence of pediatric CKD to range between 56 and 74.7 cases per million.[1] While the exact prevalence remains unknown in Indonesia, the 2013 Indonesia Basic Health Research (*Riskesdas*) reported a CKD prevalence of 0.2% among patients older than 15.[2] Peritoneal dialysis (PD) using a Tenckhoff catheter has become a viable treatment option for children with end-stage renal disease (ESRD) due to its suitability for home-based care and fewer dietary and fluid restrictions compared to routine hemodialysis.[3]

Despite its advantages, the Tenckhoff catheter is associated with several complications, such as catheter migration and infection, affecting 7–26% of patients.[4] These complications highlight the need for alternative insertion techniques to reduce associated risks. A previous study reported that leakage is the most common complication following PD catheter

insertion in children, with an incidence of 21% in infants and 8% in older children, indicating that infants are more susceptible.[5] Traditional insertion techniques, such as preperitoneal tunneling, are designed to prevent catheter migration, dislocation, and omental wrapping.[6] The laparoscopic approach offers an alternative by utilizing rectus sheath tunneling[7] or combining rectus sheath tunneling, omentopexy, and adhesiolysis.[8] However, despite these advancements, catheter-related complications remain a significant challenge, highlighting the need for an improved insertion technique that minimizes leakage, migration, and infection.

This study aimed to evaluate a novel laparoscopic Tenckhoff catheter insertion technique designed to minimize complications associated with the procedure, such as intraoperative bleeding, local wound infection, catheter leakage, peritonitis, hernia, cuff extrusion, and catheter obstruction. During the Seldinger technique, sequential dilatation using increasing dilator sizes was employed to ensure correct measurement for catheterization, facilitating precise placement and reducing insertion-related trauma. By incorporating the Seldinger method with Alken telescopic metal dilators, this approach ensures adequate space for a 15 Fr catheter to be inserted through the peritoneum with a minimally invasive approach, along with reduced leakage and migration. These physical improvements contribute to the overall physiological benefits, including enhanced catheter survival, improved procedural outcomes, and reduced failure rates. This study presents our experience with this technique and examines its potential benefits compared to existing approaches.

METHODS

Patients

This prospective observational study was conducted at Cipto Mangunkusumo Hospital from September 2018 to October 2022 and involved 33 pediatric patients (aged 1–18 years) with ESRD who underwent laparoscopic Tenckhoff catheter insertion using our novel technique with an Alken telescopic metal dilator. The minimum follow-up period was 6 months. Informed consent was obtained from parents or legal guardians in accordance with ethical guidelines. This study was approved by the Ethics Committee of the Faculty of Medicine, Universitas Indonesia – Cipto Mangunkusumo Hospital (No: KET-547/UN2.F1/ETIK/PPM.00.02/2023) following the Declaration of Helsinki.

Inclusion criteria

This study included pediatric patients aged 1–18 years diagnosed with ESRD and requiring PD. Eligibility criteria required the absence of prior significant abdominal surgeries that would contraindicate laparoscopic Tenckhoff catheter placement, as well as no active intra-abdominal infections or conditions that could increase procedural risks.

Sample size

The sample size was calculated using Cochran's formula based on the number of pediatric patients diagnosed with CKD in Indonesia. Several factors were considered in determining the sample size, including a 0.2% prevalence (0.002), a 95% confidence level, and a 1.52% margin of error (0.0152). The CKD prevalence in Indonesia was obtained from the 2013 Indonesia Basic Health Research (*Riskesdas*).[2] Sample size calculation was performed using the formula proposed by Pourhoseingholi et al, based on the estimated CKD prevalence in Indonesia.[2,9] According to the formula, the minimum required sample size for this study was 33 patients.

Surgical technique

The surgical procedure was performed by four surgeons from the Cipto Mangunkusumo Hospital pediatric urology surgical team. Initially, the team determined the incision site for the intramuscular tunnel based on previous abdominal surgical wounds, stomas, or skin conditions. While the incision is typically made on the left side, we prefer performing it on the right side to minimize postoperative complications. The proximal and distal positioning of the Dacron cuff and Tenckhoff catheter exit port was carefully planned, ensuring the exit site aligned with the catheter's natural curve in the lower abdomen. The subcutaneous cuff was positioned 2 cm distal to the Dacron cuff to prevent cuff extrusion.

A 5-mm trocar was inserted through an incision on the right abdomen, followed by the introduction of a laparoscopic camera and carbon dioxide insufflation into the intraperitoneal cavity. A laparoscopic evaluation was performed to identify adhesions, excessive omental tissue, or undiagnosed hernias.

If an additional trocar was required, a second 5-mm incision was made in the left lower abdomen under laparoscopic guidance. Excessive omental tissue was managed using a lasso tie with 1-0 Prolene. The omentum was then pulled over the first trocar and sutured to the abdominal wall for omentopexy. Persistent omental redundancy was addressed with an omentectomy using an energy device.

A paramedian incision was made at the tunneling site. In our study, the tunneling site was created using a metal telescopic dilator (Figure 1). First, a 17.5-gauge needle was inserted into the peritoneal cavity, followed by the placement of a guidewire. This method was used to facilitate rectus sheath tunneling, which involves creating a tunnel through the rectus muscle and sheath to serve as a protective pathway for the wire, minimizing damage to the surrounding tissues. Then, the Alken metal dilator was dilated until the tunnel reached a diameter of 15Fr. The dilator was then removed, and the Tenckhoff catheter was directed into the Retzius cavity, with its distal end positioned in the left lower abdomen. The Tenckhoff catheter was tested with dialysis fluid, and the peritoneal cavity was deflated. After the trocar and laparoscopic instruments were removed, the surgical wound was closed in layers.

Outcomes and follow-up protocol

Patient outcomes were assessed based on age, use of omentopexy and omentectomy, and comorbidities. Each factor was analyzed in relation to the presence of complications and catheter durability. Catheter assessment outcomes included local wound infection, catheter leakage, peritonitis, herniation, cuff extrusion, and catheter obstruction. Postoperative monitoring during the first 7 days focused on detecting signs of infection, leakage, and intra-abdominal complications. Monthly follow-up visits evaluated catheter function, complications such as infection or obstruction, and survival analysis.

Statistical analysis

Normally distributed continuous variables are presented as means (standard deviations [SDs]), whereas non-normally distributed variables are reported as medians with minimum and maximum values. The catheter survival rate was calculated from the date of laparoscopic Tenckhoff catheter insertion to its removal, with Kaplan–Meier plots estimating survival probabilities. Statistical analysis and graphics were generated using SPSS software version 26 (IBM Corp., USA). The Mann–Whitney test was used to analyze continuous numerical variables, such as mean body mass index (BMI), kidney replacement therapy duration, mean procedure time, and mean Tenckhoff catheter duration. The chi-square test was used to calculate *p*-values for categorical variables, including sex and omentopexy/omentectomy. Complication rates were analyzed using an unpaired *t*-test to determine *p*-values. Statistical significance was defined as $p<0.05$.

RESULTS

Patient characteristics

This study included 33 patients with a mean age of 11.92 years (SD: 3.7) and a median BMI of 16.74 kg/m^2 (range: 11.8–22.04). The study population had an equal distribution of men and women, with hypertension (55%) and cardiomyopathy (27%) being the most prevalent comorbidities. Table 1 presents detailed baseline characteristics (Table 1).

Procedural outcomes

The mean duration of the laparoscopic Tenckhoff catheter insertion procedure was 113.76 min, while the median duration of kidney replacement therapy before catheter placement was 5.5 days. The Tenckhoff catheter remained in use for an average of 25.9 months.

Catheter survival analysis

Kaplan–Meier analysis revealed a mean catheter survival time of 45.24 months (SD: 3.9) (Figure 2). The overall catheter survival rate was 84.8%, while the cumulative survival using this technique was 78% at 55 months. Five patients (15%) required catheter removal due to infection or malfunction, and two patients (6%) underwent kidney transplantation.

Complications

A total of seven catheter-related complications were reported in five patients, with the most common complications reported were local wound infections (12%) and peritonitis (6%). Catheter obstruction was observed in one patient. No cases of intraoperative bleeding, leakage, herniation, or cuff extrusion were recorded (Table 2). Complications were categorized according to their onset as early (occurring ≤24 hours postoperatively) or late (occurring thereafter).

Figure 1. Tenckhoff catheter insertion using Alken metal dilator. (a) Peritoneal puncture using 17.5-gauge needle; (b) Alken metal dilator insertion using guidewire; (c) Tenckhoff catheter insertion with Seldinger technique

Table 1. Baseline characteristics of patients

Baseline demographic	Tenckhoff failure		Complication		All subjects (N = 33)
	Yes (N = 5)	No (N = 28)	Yes (N = 7)	No (N = 26)	
Age (years), mean (SD)	16.03 (13.2)	12.14 (3.9)	26.71 (39)	12.5 (3.9)	11.92 (3.7)
BMI, n (%)					
Normal weight	0	5 (18)	0	5 (19)	5 (15)
Underweight	5 (100)	23 (82)	7 (100)	21 (81)	28 (85)
Male sex	3 (60)	14 (50)	5 (71)	12 (46)	17 (52)
Kidney replacement therapy duration (days), median (min–max)	3 (1–10)	5.5 (0–18)	3 (1–10)	5.5 (0–18)	5.5 (0–18)
Comorbidities, n (%)					
Hypertension	2 (40)	16 (57)	5 (71)	13 (50)	18 (55)
Cardiomyopathy	2 (40)	7 (25)	1 (14)	8 (31)	9 (27)
DM	0	1 (4)	0	1 (4)	1 (3)
Spina bifida	0	1 (4)	0	1 (4)	1 (3)
Others*	1 (20)	3 (11)	1 (14)	3 (12)	4 (12)
Omentopexy/omentectomy, n (%)	3 (60)	27 (96)	6 (86)	24 (92)	30 (91)
Procedure time (min), mean (SD)	117.81 (33.9)	113.04 (37.6)	100.57 (40.0)	117.3 (35.6)	113.76 (36.6)
Tenckhoff catheter duration (months), mean (SD)	16.03 (13.2)	22.23 (19.3)	16.99 (15.7)	11.13 (15.7)	25.89 (20.3)

BMI=body mass index; DM=diabetes mellitus; SD=standard deviation
*Others are lung tuberculosis, rheumatic heart failure, ventral septal defect, and posterior urethral valve

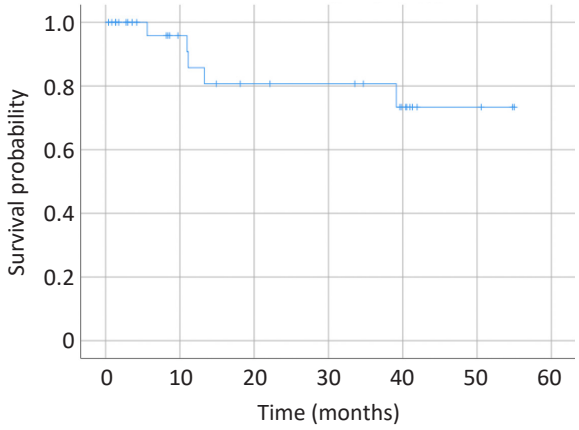

Figure 2. Kaplan–Meier survival for functional Tenckhoff catheter

DISCUSSION

This study evaluated a novel laparoscopic Tenckhoff catheter insertion technique that integrates an Alken metal dilator with the Seldinger technique and a laparoscopic approach for Tenckhoff catheter insertion. The technique demonstrated a favorable safety profile with no reports of intraoperative bleeding, leakage, herniation, or cuff extrusion. Conventionally used in percutaneous nephrolithotomy, Alken metal dilators were repurposed in our study to establish access and gradually expand the tissue tract for Tenckhoff catheter placement. This approach addressed the considerable risk of leakage (14–24%)

Table 2. Complication rates of patients

Complications	n (%) (N = 33)
Intraoperative bleeding	0
Local wound infection	4 (12)
Catheter leakage	0
Peritonitis	2 (6)
Herniation	0
Cuff extrusion	0
Catheter obstruction	1 (3)

associated with trocar-based catheter insertion. Despite its cost-effectiveness and technical simplicity, the blind insertion of a rigid, pointed trocar raises concerns about potential visceral perforation or injury, even with an experienced operator. Comparative analysis with the conventional mini-laparotomy technique revealed higher complication rates, which not only affected patient outcomes but also had implications for healthcare practitioners' reputations. This could discourage patients from choosing PD as a treatment option. A nationwide study in Brunei reported an increase in PD utilization following the implementation of peritoneoscopic techniques for catheter implantation.[10]

In settings with limited access to specialized surgeons, dedicated facilities, or financial resources, the standard percutaneous "trocar and cannula" technique offers an alternative option for Tenckhoff catheter placement.[11] However, this method has largely been replaced by percutaneous needle-guidewire techniques and laparoscopic multifascial tunneling to prevent complications and catheter dysfunction.[12] Our study demonstrates that the use of an Alken metal dilator enhances catheter durability, with only five complications observed following its application. This favorable outcome is likely attributable to the controlled dilation limited to catheter size, effectively reducing the risk of complications such as leakage or malfunction.[13]

The Tenckhoff catheter survival rate (78% at 55 months) observed in this study aligns with previous studies on laparoscopic insertion techniques. Hagen et al[14] reported that patients who underwent laparoscopic insertion experienced significantly greater long-term catheter survival, with an odds ratio of 3.93 for 1-year catheter survival. Similarly, Abdijalil and Shuijuan[15] reported a significantly lower risk of catheter malfunction in the laparoscopic group compared to the open surgery group, with a relative risk ratio of 0.58 (p = 0.03). These findings suggest that our approach offers a comparable or superior long-term survival rate. Another study reported that laparoscopic insertion of continuous ambulatory peritoneal dialysis catheters resulted in higher survival rates and fewer complications, particularly catheter migration, compared to open surgical insertion. The laparoscopic technique also resulted in shorter operative times and reduced postoperative pain.[16] These comparisons indicate that our approach offers a favorable long-term catheter survival rate, supporting its feasibility and effectiveness in clinical practice. Additionally, our complication rates, including infection-related catheter removals and peritonitis, fall within acceptable ranges compared to previous studies, reinforcing the potential advantages of this technique.

We also examined preoperative and intraoperative factors that could influence complications. Our study showed that omentum-related procedures, including omentopexy and omentectomy, were significant contributors to catheter failure. A recent study in India involving 16 patients who underwent laparoscopic PD catheter insertion with omentectomy reported longer operative times than those without omentectomy (mean [SD]: 59.7 [33] *versus* 34.2 [14.1], p<0.001). However, the study suggested that performing omentectomy during laparoscopic insertion might reduce the risk of catheter malfunction.[17] Our study yielded similar findings, with omentectomy adding approximately 26 min to the procedure. No intraoperative complications occurred across all cases, further supporting the safety of combining laparoscopic PD catheter implantation with omentectomy.

A recent collaborative multicenter study in the USA reported an early PD peritonitis incidence rate of 8.4% within 60 days of catheter insertion.[18] Similarly, our study recorded a relatively modest incidence of early PD peritonitis within 3 months at 6%, which was consistent across all three study groups. In contrast, a study from Turkey reported a significantly higher peritonitis rate of 75% for open insertion compared to 25% for laparoscopic insertion. This disparity in peritonitis rates may be attributed to the extended 12-year duration of the Turkish study, which resulted in a longer follow-up period.[19]

This study has several limitations. First, it was conducted at a single center, which may limit the generalizability of the findings to other clinical settings

with different resources and surgical expertise. Second, the small sample size of 33 pediatric patients reduces the statistical power of the study and limits the applicability of the findings to larger populations. Additionally, the study lacked a control group utilizing conventional catheter insertion techniques, making it difficult to directly compare outcomes and fully evaluate the potential advantages of this novel approach. Although the follow-up period was sufficient to assess initial outcomes, it may not have been long enough to detect late complications or assess long-term catheter durability. To strengthen these findings, larger scale, multicenter studies with extended follow-up periods are needed to provide a more comprehensive understanding of the technique's effectiveness and safety. Finally, our study focused solely on a single novel catheter insertion method. Further investigations in diverse populations and clinical settings are necessary. While our results suggest favorable catheter survival and low complication rates, these outcomes should be interpreted with caution until additional studies confirm the potential benefits of this approach.

In conclusion, this study highlights the challenges in pediatric CKD treatment, particularly donor shortages in Indonesia, and underscores the importance of alternative treatments such as PD. Our study introduced a novel catheter insertion method that reduced complications, such as leakage, and achieved a low (6%) early PD peritonitis rate. The variability in results across different studies underscores the need for standardized insertion techniques to improve patient outcomes. Future studies with larger sample sizes, multicenter collaboration, and long-term follow-up are needed to validate these findings and further refine the technique.

Conflict of Interest

The authors affirm no conflict of interest in this study.

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