Original Article

The efficacy and safety of an improved percutaneous peritoneal dialysis catheter placement technique in urgent-start peritoneal dialysis patients: a retrospective cohort study

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Background: Urgent-start peritoneal dialysis has high catheterization skill requirements and that early complications. The optimal catheter placement method remains debatable in urgent-start peritoneal dialysis patients. Safe and effective peritoneal dialysis catheterization is needed in clinical work.

Methods: We retrospectively analyzed the data of 34 patients diagnosed with end-stage renal disease who opt for peritoneal dialysis, 19 males and 15 females, with an average age of 62.3±14.7 years, peritoneal dialysis catheter implantation was completed by the improved percutaneous catheterization technique. They were followed for 6 months, early and late complications were observed and the survival rate of the catheter technique was calculated.

Results: All 34 patients diagnosed with end-stage renal disease successfully underwent catheter placement using the improved percutaneous technique; the catheterization success rate was 100%. No severe organ injuries, such as intestinal perforation and bladder perforation, occurred intraoperatively. Peritoneal dialysis was started immediately after surgery. The early complications included one case of leakage, one case of omental wrapping, and six cases of rectus abdominis hemorrhage. The late complications included one case of pleuro-abdominal fistula and two cases of peritonitis. The 6-month technical survival rate for the catheter was 94.1% (32/34). Compared to previously reported studies, this technique may reduce leakage and early catheter dysfunction, and improve the technical survival of catheters.

Conclusions: The improved percutaneous peritoneal dialysis catheter placement technique might be an effective and safe method for urgent-start peritoneal dialysis patients.

Keywords: Peritoneal dialysis; urgent start; percutaneous puncture; artificial ascites; rectus sheath tunneling

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Introduction

Globally, the incidence of end-stage renal disease continues to increase. However, due to low rates of awareness and other factors, approximately 40% of patients with new-onset end-stage renal disease must receive urgent-start dialysis (1). Urgent-start hemodialysis via central venous catheterization is still the main treatment (2,3). It refers to peritoneal dialysis treatment that is started within 2 weeks after the completion of peritoneal dialysis catheterization (4). Compared with urgent-start hemodialysis, urgent-start peritoneal dialysis eliminates the need for central venous catheterization and offers unique advantages in terms of catheter infection (5). However, a study has shown that urgent-start peritoneal dialysis has high catheterization skill requirements and that early complications, such as catheter dysfunction and leakage, are significantly higher among urgent-start peritoneal dialysis

patients compared to non-urgent-start peritoneal dialysis patients (6), which restricts the development of urgent-start peritoneal dialysis to a large extent.

In recent years, laparoscopic and percutaneous puncture techniques have been widely used in peritoneal dialysis catheter placement. However, for urgent-start peritoneal dialysis, there is still no suitable catheter placement method. Reducing the early complications after catheterization and improving the catheter survival rate are particular focuses of related research. In this study, we improved the percutaneous peritoneal dialysis catheterization technique, low-position catheter placement by rectus sheath tunnel, double purse-string suture for the anterior rectus abdominis sheath, and artificial ascites used to create a space for catheter placement, with the aid of ultrasound imaging to guide the entire peritoneal dialysis catheter placement process. These improvements may reduce the early complications of urgent-start peritoneal dialysis and improve the survival rate of catheterization. We present the following article in accordance with the STROBE reporting checklist (available at https://apm.amegroups.com/article/view/10.21037/apm-22-1270/rc).

Methods

Study subjects

A total of 34 patients with end-stage renal disease who started peritoneal dialysis in our hospital between March 1, 2018, and January 31, 2019, were selected, including 19 males and 15 females, with an average age of 62.3±14.7 years, the average body mass index (BMI) was 20.8±3.6 kg/m^2. They completed the peritoneal dialysis catheter placement with an improved percutaneous catheterization technique and initiated peritoneal dialysis therapy immediately after surgery. A 6-month follow-up was then conducted, early and late complications were observed and the survival rate of the catheter technique was calculated. The inclusion criteria were as follows: (I) confirmed end-stage renal disease; (II) catheterization completed using the improved percutaneous peritoneal dialysis catheterization technique; and (III) peritoneal dialysis started immediately after catheterization. Patients with a history of major abdominal surgery and abdominal adhesions were excluded. All patients signed a surgical informed consent form. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Ethics Committee of Ningbo First Hospital (No. 2018-R057). Individual consent for this retrospective analysis was waived.

Highlight box

Key findings

- The technique may be safe and effective in urgent-start peritoneal dialysis patients.

What is known and what is new?

- The optimal catheter placement method remains debatable in urgent-start peritoneal dialysis patients.
- The technique may reduce leakage and early catheter dysfunction, improve the technical survival of catheters.

What is the implication, and what should change now?

- The technique may be worthy of clinical promotion.

Equipment

The following equipment was used: (I) Mindray M9 color Doppler ultrasound system; (II) Baxter medCOMP set (REF MPD-242-C) peritoneal dialysis catheter set; and (III) straight 2-cuff Tenckhoff peritoneal dialysis catheter.

Preoperative preparation

Preoperative examinations [routine blood, coagulation function, liver and kidney function, electrolytes, complete abdominal computed tomography (CT), and other imaging examinations] were performed to exclude surgical contraindications. An abdominal ultrasound was conducted preoperatively to observe the degree of subperitoneal bowel movement. The vascular path under the abdominal wall was traced on the body surface, and the puncture point and catheter exit location were marked (*Figure 1*).

Surgical procedure

All catheterization procedures were performed under local anesthesia by the same two nephrologists. (I) The puncture point was 2 cm next to the white line 10 cm above the pubic symphysis, and the catheter entrance into the abdominal cavity was placed 4 cm below the puncture point. The abdominal dialysis catheter was placed 4 cm into the rectus abdominis muscle (*Figure 1A*). (II) Surgical procedure: lidocaine (2%) was used for local anesthesia. Approximately, 1–2 cm of the skin was incised at the puncture site, the subcutaneous tissue was separated, and the anterior rectus abdominis sheath was exposed. A double purse-string

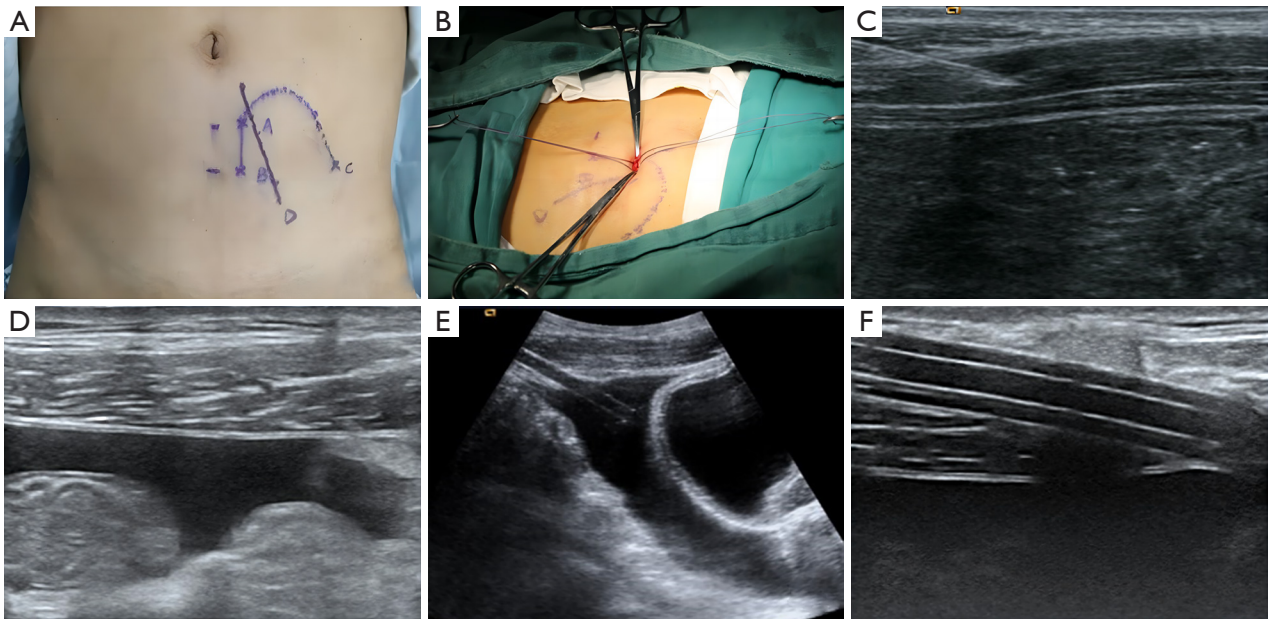

Figure 1 Procedure of percutaneous peritoneal dialysis catheterization. (A) Body surface location. A: skin incision; B: abdominal cavity entrance; C: skin exit for the catheter; D: body surface tracing of the inferior abdominal wall artery. (B) Premade double purse suture in the anterior rectus abdominis sheath. (C) The puncture needle was advanced into the rectus abdominis. (D) Artificial ascites was established. (E) The peel-away sheath was inserted with the assistance of artificial ascites. (F) The peritoneal dialysis catheter was submerged into the rectus abdominis muscle.

suture was premade in the anterior rectus abdominis sheath (*Figure 1B*). An 18-G puncture needle was inserted through the center of the purse-string suture at a downward angle of approximately 15°. The needle was passed through the rectus abdominis under ultrasound guidance (*Figure 1C*), carefully avoiding the large blood vessels in the rectus abdominis muscle.

Next, the posterior rectus abdominis sheath was punctured, and the needle was inserted 4 cm downward into the rectus abdominis muscle and then into the abdominal cavity. After injecting 100 mL of saline, a guide wire was inserted, the puncture needle was withdrawn, and a dilator with a peel-away sheath was placed along the guide wire. Peritoneal dialysate (1.5%) was continuously injected into the abdominal cavity through the peel-away sheath, and artificial ascites was established using the patient's body position and gravity (*Figure 1D*). The peel-away sheath was gradually advanced against the abdominal wall toward the pelvic floor under ultrasound guidance (*Figure 1E*), avoiding direct contact with the intestinal canal, bladder, and other abdominal organs. The guide wire was then reinserted, and the peritoneal dialysis catheter was inserted through the peel-away sheath along the guide wire. After confirming that the catheter was in place under ultrasound (rigid guidewire guidance was used if it was not in place), the guidewire was withdrawn, and the sheath was removed.

Subsequently, the inner cuff of the peritoneal dialysis tube was inserted into the rectus abdominis using a vascular clamp (*Figure 1F*). The purse-string suture on the anterior rectus abdominis sheath was tightened. A subcutaneous tunnel was then made, through which the peritoneal dialysis tube was passed to connect to a titanium connector and a short external tube. About 1,000 mL of abdominal dialysis fluid was drained to reduce abdominal pressure, and the remaining peritoneal dialysis fluid was retained in the abdomen. The catheter was closed, the subcutaneous tissue and skin were sutured, and the position of the end of the catheter was again confirmed via ultrasound, after which the placement was considered complete.

The main improvements in the technique were as follows

(I) Low-position catheter placement after ultrasound-guided construction of the rectus sheath tunnel; (II) double purse-string suture for the anterior rectus abdominis sheath; and (III) artificial ascites used to create a space for catheter

Table 1 Basic information of the included patients

Items	Value
Age (years), mean ± SD	62.3±14.7
Sex (male/female), n	19/15
BMI (kg/m^2), mean ± SD	20.8±3.6
Primary disease, n	34
Glomerulonephritis	14
Diabetes	10
Hypertension	3
Polycystic kidney	2
Other	5

SD, standard deviation; BMI, body mass index.

placement, with the aid of ultrasound imaging to guide the entire peritoneal dialysis catheter placement process.

Abdominal dialysis regimen

Immediately after surgery, residual peritoneal dialysis fluid in the abdominal cavity was drained from all patients, followed by two 500-mL washes. Intermittent peritoneal dialysis (IPD) was started immediately if the washing solution was not bloody and the drainage flowed well. A total of 1,000 mL of peritoneal dialysis solution was perfused each time and retained in the abdomen for 3 hours, with four cycles daily for 3 days. All patients were required to remain in the supine position during the first 3 days of abdominal dialysis. Starting on the 4th day, 1,500 mL of peritoneal dialysis solution was perfused each time and retained in the abdomen for 4 hours, with four cycles daily for 4 days. Standard continuous ambulatory peritoneal dialysis (CAPD) treatment was started on day 8, with 2,000 mL of peritoneal dialysis fluid infused each time (four cycles per day).

Observation indicators

The observation indicators included early complications, such as leakage, catheter displacement, omental wrapping, rectus abdominis hemorrhage, outlet or tunnel infection, peritonitis, etc. Each patient was examined once daily during the first 2 weeks after surgery. After peritoneal dialysis was officially performed, examinations were performed once per month. Displacement of the catheter was primarily determined using abdominal plain radiographs, which were obtained on postoperative day 1 and postoperative day 14, and any time a drainage obstruction occurred thereafter.

Statistical analysis

SPSS statistical software was used for the statistical analyses. Continuous variables were presented as the mean ± standard deviation (SD), and non-continuous variables were presented as percentages. The main analyses were descriptive, the normality of continuous variables was tested by one-sample Kolmogorov-Smirnov test.

Results

The basic information of the 34 patients is shown in *Table 1*. All patients started low-dose peritoneal dialysis immediately after surgery and were followed up for 6 months after surgery. All complications were divided into early stage (within 1 month) and late stage (after 1 month). The following early complications were observed: one case of leakage, which improved after adjusting the peritoneal dialysis regimen; one case of omental wrapping, which required laparoscopic replacement and resection of the omentum; and six cases of rectus abdominis hemorrhage, all of which improved after bed rest and abdominal irrigation (no serious bleeding occurred). The late complications included one case of pleuro-abdominal fistula, leading to the termination of peritoneal dialysis and initiation of hemodialysis treatment, and two cases of peritonitis, resulting in the continuation of peritoneal dialysis after anti-infection treatment (*Table 2*). After excluding death (one case) and kidney transplantation (one case), the 6-month catheter technical survival rate was 94.1% (32/34).

This study did not use a control group. A literature review indicated that there are relatively numerous studies on urgent-start peritoneal dialysis in other countries. *Table 3* provides a comparison of the information and data obtained in this study with those from other published studies.

Discussion

Urgent-start peritoneal dialysis has several advantages. Firstly, it is a simple technique that provides early survival benefits and a better quality of life (11) and protects residual renal function (12). Compared to hemodialysis, it has lower incidences of catheter-related infections and mechanical complications (5), a lower incidence of bacteremia (13),

Table 2 Early and late complications after peritoneal dialysis catheter placement

Complications	Early stage (within 1 month), n (%)	Late stage (after 1 month), n (%)
Leakage	1 (2.9)	0
Catheter displacement	0	0
Omentum wrapping[a]	1 (2.9)	0
Rectus abdominis hemorrhage[b]	6 (17.6)	0
Perforation of abdominal organs	0	0
Pleuro-abdominal fistula[c]	0	1 (2.9)
Peritonitis[d]	0	2 (5.9)
Outlet or tunnel infection	0	0

[a], after conservative treatment failure, the catheter was reinserted after laparoscopic omentectomy; [b], all cases manifested as bloody peritoneal dialysis fluid, which improved after conservative treatment and did not require surgical intervention; [c], conservative treatment was ineffective; peritoneal dialysis was stopped and changed to hemodialysis; [d], the incidence of peritonitis was 0.24/(person·year).

Table 3 Comparison of data between this study and other urgent-start peritoneal dialysis studies

Literature	Sample size	Catheterization method	Dialysis start time	Follow-up time	Mechanical complications	Infectious complications	Technical survival of catheters
This study	34	Improved percutaneous puncture	Immediately after catheterization	6 months	Leakage, 2.9%; catheter dysfunction, 2.9%	Peritonitis, 5.9%	94.1%
Povlsen, 2006 (7)	52	Surgery	Within 24 h after catheterization	3 months	Leakage, 7.7%; catheter dysfunction, 15.4%	Peritonitis, 15.4%	86.7%
Nayak, 2018 (8)	32	Surgery	48 h after catheterization	3 months	Leakage, 9.4%; catheter displacement, 25.0%	Peritonitis, 9.4%	90.6%
Song, 2000 (9)	21	Percutaneous puncture	Immediately after catheterization	12 months	Leakage, 9.5%; catheter dysfunction, 4.8%	Peritonitis, 23.8%	85.7%
Ghaffari, 2012 (4)	18	Percutaneous puncture	Within 2 weeks after catheterization	3 months	Leakage, 33.3%; catheter dysfunction, 11.2%	Peritonitis, 3.6%	–
Bitencourt, 2017 (10)	51	Percutaneous puncture	Within 72 h after catheterization	6 months	Leakage, 9.7%; catheter dysfunction, 15.6%	Peritonitis, 7.8%	86.3%

no increase in patient mortality (14), and lower treatment costs (15). It has become an important alternative treatment for end-stage renal disease. For those who choose peritoneal dialysis as a long-term renal replacement therapy, urgent-start peritoneal dialysis has gradually become an important alternative (16). However, current urgent-start dialysis is still predominantly hemodialysis, and peritoneal dialysis is underutilized (17). Numerous factors affect the choice of urgent-start peritoneal dialysis among nephrologists, of which ease of catheterization and fewer postoperative catheter complications are the main factors.

Currently, there are a variety of catheter placement methods used in urgent-start peritoneal dialysis, including surgical methods, laparoscopic methods, and percutaneous puncture. However, the optimal catheter placement method remains debatable (18,19). Percutaneous puncture is mainly used in foreign countries, while surgery is the primary method used in China. Since percutaneous puncture results in less trauma and quick recovery, it only requires local anesthesia and can be completed at the bedside, and is especially suitable for urgent-start dialysis patients. Also, in contrast to laparoscopic and surgical methods, placement via percutaneous puncture is similar to cuff placement for central vein hemodialysis and is easier for nephrologists to

perform. One study has suggested that compared with that for surgeons, the start application time of peritoneal dialysis catheters inserted by nephrologists is earlier and that the technical survival rate is higher (20). However, percutaneous catheter placement, whether using the Seldinger method or the exchange method, is a blind method because there is no guidance, and severe abdominal organ damage, such as intestinal (21) and bladder (22) perforation, may occur during the catheterization process.

In this study, ultrasound guidance was used throughout the catheter placement process, providing a clear visualization of the abdominal cavity during the puncture needle entry procedure. In addition, the use of artificial peritoneal fluid assists in creating a liquid space, allowing visualization of the entire catheter placement process, thereby improving safety and avoiding the risk of abdominal organ damage. All procedures in this study were completed by the same two nephrologists, and the catheter placement success rate was 100%. No abdominal organ injury occurred during the catheterization process. These results suggest that percutaneous peritoneal dialysis catheter placement under ultrasound guidance and artificial ascites is safe and reliable.

Catheter-related complications after peritoneal dialysis, especially catheter dysfunction, affect the application of urgent-start peritoneal dialysis. Studies have shown that compared with planned dialysis, urgent-start peritoneal dialysis has a higher incidence of catheter dysfunction and recatheterization (6), with an incidence of mechanical complications as high as 25.7% (11). Alkatheeri *et al.* (23) found that the incidence of catheter displacement in urgent-start peritoneal dialysis was as high as 20%. Moreover, a study has shown that laparoscopic-assisted abdominal internal fixation of the catheter or the establishment of rectus sheath tunnels reduce the occurrence of postoperative catheter displacement (24). However, these adjuvant measures require laparoscopy, and the establishment of a rectus sheath tunnel during percutaneous catheter placement has not been reported. The present study is the first to establish a rectus abdominis tunnel by ultrasound guidance; the catheter enters the abdominal cavity after being inserted downward approximately 4 cm into the rectus abdominis muscle, thereby fixing the catheter at two points. The position of the abdominal cavity entrance is low, and the intra-abdominal catheter is short, resulting in a very low incidence of catheter displacement. Even if the catheter temporarily displaces due to factors such as severe intestinal distension, it can be quickly reset by pressure after removing the suture. Another advantage of the low-entering position of the peritoneal catheter into the peritoneal cavity is that it effectively avoids and reduces irritation to the omentum, resulting in a low incidence of omental wrapping, which reduces the incidence of catheter dysfunction. In this study, only one case of omental wrapping occurred, and no catheter displacement was observed. The incidence of mechanical complications was significantly superior to those reported in other published percutaneous catheter placement studies (4,10,11).

Leakage is another important factor leading to the failure of early peritoneal dialysis. It can induce outlet infection, tunnelitis, and peritonitis in severe cases. This problem is particularly serious in urgent-start peritoneal dialysis. Therefore, both the European Best Practice Guidelines (EBPG) and the 2010 International Society for Peritoneal Dialysis (ISPD) guidelines recommend that peritoneal dialysis be initiated 2 weeks after surgery to reduce the occurrence of leakage (25,26). The main causes of leakage include the catheterization technique, the initial peritoneal dialysis regimen, and abdominal wall weakness (27,28). A study by Ghaffari *et al.* (4) found that compared with a non-urgent-start peritoneal dialysis group, the urgent-start peritoneal dialysis group had a higher incidence of leakage. Excessive incision and poor ligation of the peritoneum and posterior rectus abdominis sheath can lead to an increased risk of leakage (29). The incision in the surgical approach is inevitably relatively large, while in laparoscopic placement, a laparoscopic access or manipulation hole needs to be established in addition to the catheter entrance.

In this study, the percutaneous puncture method was used to place the catheter. The diameter of the dilating sheath was basically the same as the inner diameter of the peritoneal dialysis catheter; therefore, the tear in the peritoneum and the posterior rectus abdominis sheath was small, and the catheter could be tightly wrapped after placement. The long rectus sheath tunnel allowed the deep cuff of the catheter to be encased by the rectus abdominis; additionally, a double purse-string suture was tied on the anterior rectus abdominis sheath. With improvements in these measures, even small amounts of dialysate leakage are confined to the sheath of the rectus abdominis, with no subcutaneous outlet, thereby reducing the occurrence of leakage. Peritoneal dialysis was started immediately after surgery for all patients in this study, and only one case of leakage occurred (incidence rate, 2.9%), suggesting that these improved measures effectively reduce the occurrence of postoperative leakage, especially for urgent-start

peritoneal dialysis. In addition to the improvements in the catheterization technique, we also made appropriate adjustments in the formulation of the initial peritoneal dialysis regimen. The dose for the first 3 days was relatively small (4 L per day), which was then gradually increased, and the standard CAPD treatment was started after 1 week. In addition, during the first 3 days of peritoneal dialysis, all patients remained in the supine position, which may explain the low incidence of leakage observed in this study.

In terms of infection-related complications, a previous prospective study involving 30 patients with urgent-start peritoneal dialysis showed that no peritonitis or exit tunnel infection occurred within 4 weeks after catheterization (23). In this study, there was no exit tunnel infection or peritonitis in the early stage after catheterization. Peritonitis occurred in two patients in the late stage. The incidence rate of peritonitis was 0.24/(person·year), which was lower than the requirement of 0.5/(person·year) of the ISPD (30). Considering that leakage is associated with exit tunnel infection and early peritonitis, we speculate that the low incidence of infection-related complications in this study is related to the low incidence of early leakage.

Moreover, six patients in this study had rectus abdominis hemorrhage (incidence rate, 17.6%), and all cases occurred in the early stage after surgery, which may be related to the rectus sheath tunnel used in the surgery. Since the creation of a rectus sheath tunnel requires long-distance placement within the rectus abdominis muscle, the risk of vascular injury is increased within the rectus abdominis muscle. Messana *et al.* reported three cases of inferior abdominal wall artery injury after percutaneous catheter placement. They suggested that "Blind" puncture might be the main cause of such complications (31). Although the six patients in the present study had rectus abdominis hemorrhage, the injury was not to the inferior abdominal wall artery; therefore, there was no serious bleeding. All bleeding was controlled by bed rest and abdominal irrigation, which may be related to our routine preoperative ultrasound tracing of the inferior abdominal wall artery as well as intraoperative ultrasound guidance during the entire procedure.

Different centers have reported different data on the start time for urgent-start peritoneal dialysis. The earlier peritoneal dialysis is started after surgery, the greater the risk of early catheter complications. Therefore, most centers choose to start dialysis 24–48 h after catheter placement. However, the application of urgent-start peritoneal dialysis is limited due to the excessively long intermittent waiting time. In this study, an immediate postoperative dialysis method without an intermittent transition period was applied, and satisfactory results were obtained. We hypothesize that this was primarily due to improvements in catheter placement; additionally, the rational prescription of a dialysis regimen is also very important.

This study has some limitations that should be noted. As this was a single-center retrospective study, there was no control group, the sample size was small, and the follow-up time was short. Therefore, our conclusions may require further verification by additional clinical studies.

Conclusions

In summary, for urgent-start peritoneal dialysis, the improved percutaneous peritoneal dialysis catheter placement technique described herein is effective, safe, and easy to manage. Also, is it suitable for nephrologists because it effectively reduces leakage and early catheter dysfunction, reduces the rate of recatheterization, improves the technical survival of catheters, and thus, is worthy of clinical promotion.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://apm.amegroups.com/article/view/10.21037/apm-22-1270/rc

Data Sharing Statement: Available at https://apm.amegroups.com/article/view/10.21037/apm-22-1270/dss

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://apm.amegroups.com/article/view/10.21037/apm-22-1270/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Ethics

Committee of Ningbo First Hospital (No. 2018-R057). Individual consent for this retrospective analysis was waived.

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