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NEPHROLOGY - ORIGINAL PAPER

The "Half-Perc" technique using a simple modified metal trocar for peritoneal dialysis catheter placement: results of a 3-year follow-up of 280 patients and a literature review

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Abstract

Purpose There is an ongoing debate about the ideal technique for peritoneal dialysis (PD) catheter insertion in patients with end-stage renal disease (ESRD). A half-percutaneous ("Half-Perc") technique shares some of the advantages of both percutaneous technique and traditional open surgery. This retrospective study aimed to evaluate the clinical feasibility, safety, and effects of the "Half-Perc" technique for PD catheter placement, and to compare the clinical outcomes of the "Half-Perc" technique with various imaging-assisted percutaneous techniques from the current literature.

Methods We included 280 consecutive patients with ESRD who underwent the "Half-Perc" insertion of the first PD catheter between September 2016 and September 2019. We recorded baseline characteristics, operative parameters, catheter-related complications, catheter survival, and the reason behind PD cessation.

Results We included 174 men and 106 women, with a mean age of 50.4 years (range, 11–85 years). The mean operative time was 28.8 min (range, 15–38 min) and technical success rate was observed in 278 patients (99.3%). There were 28 episodes (10%) of mechanical complications with initial catheters occurring during the follow-up. Catheter malfunctions were the most common mechanical complication and were observed in 15 patients. Peritonitis was the most frequent catheter-related complication, with 32 episodes of peritonitis observed in 29 (10.4%) patients. After a mean follow-up period of 15.4 months (range, 2–36 months), 235 patients (83.9%) survived with their initial PD catheter by the end of the study. Of the 280 patients analyzed, 35 patients (12.5%) ceased PD at some stage during follow-up. The most common reason for PD cessation was kidney transplantation (18 patients (6.4%)), followed by death (9 patients (3.2%)) and switch to hemodialysis (HD) (7 patients (2.5%)), and recovery of renal failure (1 patient (0.4%)).

Conclusion The "Half-Perc" technique, including a modified metal trocar, is a simple, safe, and effective method for PD catheter placement that can be used for patients with ESRD.

Keywords Peritoneal dialysis · "Half-Perc" catheter placement · Catheter-related complications · Catheter survival · End-stage renal disease

Introduction

Peritoneal dialysis (PD) is a well-accepted renal replacement therapy used in patients diagnosed with end-stage renal disease (ESRD) [1, 2]. It has fewer restrictions on timing and location, better protection of residual renal function [3], a slight survival advantage within the first 2 years of dialysis initiation [4], and lower costs than hemodialysis (HD) [5]. Successful PD results from a safe, well-functioning and reliable access to the peritoneal cavity, which in turn depends on the catheter insertion technique used [6, 7].

During the past few decades, several PD catheter insertion techniques, such as open surgical placement,

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peritoneoscopic procedures, surgical laparoscopies, and the percutaneous Seldinger or trocar methods, have been used and modified to minimize the risk of catheter-related complications [6, 8]. Each method has its advantages and limitations and results in postoperative complications. However, the ideal option for PD catheter insertion remains controversial. Traditional open surgical placement is a simple, low-cost modality that does not require advanced equipment [9]. This method is suitable for patients who have previously undergone abdominal surgery and face high morbidity due to catheter malposition [10]. Both the peritoneoscopic and surgical laparoscopic approaches are minimally invasive that allow full visualization of the peritoneal cavity during catheter insertion [11, 12], along with adjunctive procedures that prevent catheter blockage or migration [13]. However, these approaches require special equipment, advanced technique and are costly [14]. The percutaneous technique is considered a fast, minimally invasive, and safe approach but results in a high risk of intestinal perforation and dialysate leakage in the past decade, whereas it remains debated recently [15]. In addition, percutaneous placement is not generally suitable for patients with ESRD who have a history of major abdominal surgery or severe obesity [16]. The trocar method has also often been used by nephrologists for PD catheter placement [17]. Although it is easy to perform and learn, this method may lead to increased incidence of bowel perforation since it enters the abdominal cavity blindly. Therefore, a definitive, evidence-based recommendation for the most optimal insertion technique is warranted.

The department of nephrology has used multiple surgical methods related to PD catheter placement since the PD center at Guangdong Provincial Hospital of Chinese Medicine was established in 2008. A new half-percutaneous ("Half-Perc") technique based on a modified trocar device, which was first introduced and self-developed by Zhu Bai et al. in 2002 [18, 19]. The "Half-Perc" technique shares some of the advantages of both the percutaneous technique and the traditional open surgery for PD catheter placement, including shorter operation duration and generally minimal tissue trauma, which results in less pain, quick postoperative recovery, and minimal lead time. Today the "Half-Perc" technique has become an alternative method used by nephrologists at our PD center since 2015. Our previous work indicated that this novel percutaneous technique is easy, safe, and effective during the perioperative period [20, 21]. However, the long-term clinical effects for PD catheter insertion were not apparent, nor was it clear at the time whether this method is superior to other imaging-assisted percutaneous techniques. In this study, we report the 3-year follow-up data of the "Half-Perc" catheter insertion technique and review the current literature on these techniques.

Patients and methods

Study population

A retrospective and observational study of "Half-Perc" PD catheter insertions was conducted at the PD center of Guangdong Provincial Hospital of Chinese Medicine, the Second Affiliated Hospital of Guangzhou University of Chinese Medicine, Guangzhou, China from 20 September 2016 to 19 July 2019. During the time period, 298 patients with ESRD undergone a "Half-Perc" catheter placement. Inclusion criteria were: (1) patients diagnosed with ESRD and who were willing to choose PD at the initiation of dialysis therapy and (2) patients receiving their first PD catheter placement. Exclusion criteria were: (1) patients followed up for less than 2 months from the first PD therapy for any reason; (2) patients unwilling to be followed-up at Guangdong Provincial Hospital of Chinese Medicine at the initiation of PD. We excluded 18 patients and analyzed data from 280 patients. Figure 1 represents a flow diagram for this study. All patients provided informed consent for participation in this study, and the study was approved by the Institutional Ethics Review Boards of Guangdong Provincial Hospital of Chinese Medicine, the Second Affiliated Hospital of Guangzhou University of Chinese Medicine (ZE2019014-01).

The "Half-Perc" procedure

The same group of three nephrologists performed operations. An experienced, senior, attending nephrologist familiar with the "Half-Perc" catheter placement technique was part of this group. Prophylactic antibiotics, usually cephalosporin, were administered before the procedure [22]. All patients in this study received the standard double-cuffed straight Tenckhoff catheter (Covidien, Mansfield, MA, USA). The length between the two cuffs is 7 cm, with a 15 cm intra-abdominal segment.

The "Half-Perc" placement of the PD catheter was based on a reusable modified metal trocar device, consisting of one central trocar, one outer sleeve with two halves and one hoop, as illustrated in Fig. 2. Details of the "Half-Perc" technique were previously described [20, 23]. Briefly, patients were placed in the supine position, and surgery was performed under local anesthesia using 1% lidocaine with 30 ml. Some risk factors, such as obesity level, abdomen circumference, lifestyle, and history of abdominal surgery, were taken into consideration before making incision. A 2 cm para-median incision site was usually generated in the abdomen 10–12 cm above the pubic symphysis or 2 cm

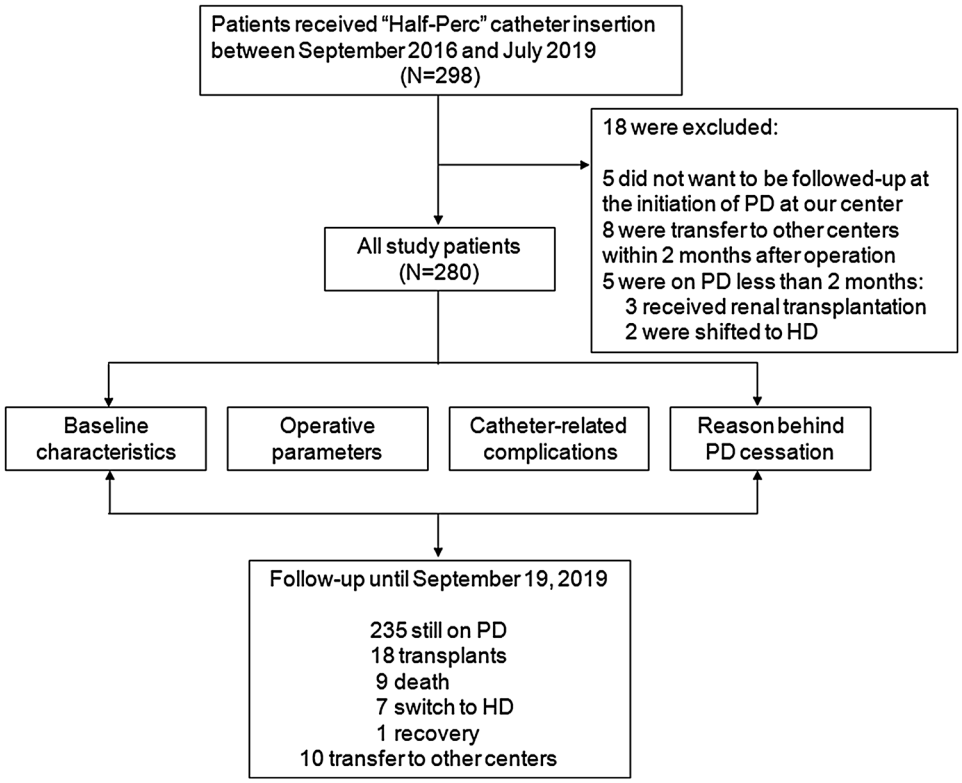

Fig. 1 Study flow diagram

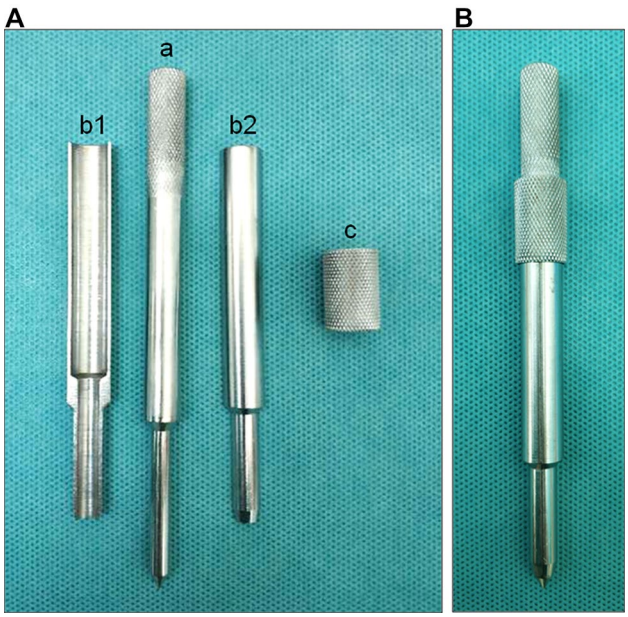

Fig. 2 Details of the modified metal trocar device. **A** The components of the trocar: (**a**) a central trocar with a sharp obturator. With a length of over 10 cm, the front-end of the central trocar was 3 cm long and 7 mm in inside diameter, and the tail-end was 7 cm long and 1.1 mm in inside diameter. (**b**) an outer sleeve created by two halves. (**c**) a hoop. **B** Configuration of the trocar

inferior to the umbilicus if necessary. A small incision of approximately 0.5 cm in length was made in the anterior rectus sheath, and a purse-string suture with a diameter of ~ 0.5 cm was placed but not tightened. The rectus muscle was dissected bluntly using a straight hemostat until the posterior layer of the rectus sheath and parietal peritoneum were seen clearly. Patients were asked to inflate their abdomen and a modified metal trocar device then inserted through the dissected rectus muscle, and the posterior rectus sheath and parietal peritoneum were slowly punctured by 1–2 mm into the peritoneal cavity using a sharp obturator within the trocar. At that time, an obvious empty sensation is felt. After peritoneal entry, the central trocar is removed leaving a sleeve created by two halves to allow catheter insertion. A metallic stylet (60 cm long and 2 mm thick) over which the PD catheter is fed was then vertically inserted into the peritoneal cavity ~ 5 cm through the hollow sleeve. The outer sleeve inclined on the upper abdominal wall at a 30 – 45° angle and the PD catheter was slowly pushed into the true pelvic cavity with the guidance of the metallic stylet. The correct positioning of the inserted PD catheter was tested with in-and-out instillation of warm saline. The peritoneal cavity was rapidly injected with 150 ml of warm saline to observe whether the solution was quickly aspirated through the catheter lumen. At the same time, we asked the patients about their perceptions to ensure whether they had strong sensations of needing to urinate and defecate.

The purse-string was sutured to fix the peritoneal catheter and ensure that the inner cuff was implanted into the rectus muscle. A subcutaneous tunnel tract was generated at the upper and outer edge followed with lower and outer edge of the incision site using a tunnel needle, and the exit site was placed over 2–3 cm from the outer cuff. The incision was surgically stitched. A regular PD program commenced immediately after surgery, if necessary.

Data collection

Patient information was manually collected by reviewing hospital electronic medical records. All baseline data were obtained during the first 1–3 months of PD. The following factors were analyzed: (1) baseline characteristics including sex, age, body mass index, primary disease, history of previous abdominal surgeries, and laboratory indicators; (2) operative parameters including operative time, incision length, bleeding volume, postoperative pain degree, use of analgesics, technical success rate, operative costs, and time to PD start; (3) mechanical complications including catheter migration, catheter blockage, omental wrapping, tube kinking, abdominal bleeding, dialysate leakage, hernias, outer cuff extrusion and inflow/outflow pain; (4) infectious complications including peritonitis, and exit-site or tunnel infections; (5) overall catheter survival and the reason behind any PD cessation.

Definitions

(1) Operative time: duration from skin detergent preparation to skin wound closure.
(2) Postoperative pain degree: measured by the visual analog scale (VAS) of 0–10. No pain: VAS 0; Mild pain: VAS 1–3, tolerable during daily activity; Moderate pain: VAS 4–6, intolerable during daily activity and affecting the ability to sleep; and Severe pain: VAS 7–10, intolerable during rest and seriously affecting the ability to sleep.
(3) Use of analgesics: oral analgesics such as aminophenol tramadol as a first-line treatment for moderate pain, and intramuscular tramadol hydrochloride injection for severe cases.
(4) Bleeding volume: a piece of gauze (size: 9 cm * 33 cm * 4 layers), which was fully covered with blood, is estimated to be approximately 20 ml of blood.
(5) Technical success rate: successful in-and-out test, which the peritoneal cavity was rapidly injected with 150 ml of warm saline and the solution was quickly aspirated through the catheter lumen during the "Half-perc" procedure.
(6) Time to start PD: duration from catheter insertion to the start of a regular PD program after surgery (days).
(7) Overall catheter survival: functionality and survival of the initial catheter before loss for any reason, such as renal transplantation, switch to HD, renal recovery or death. Transfer to other PD centers is defined as censored data.

Search strategy and selection criteria

We searched the electronic databases PubMed, Embase, and CNKI for articles published from January 1, 2008 to June 5, 2020. To evaluate the postoperative outcomes between catheters placed by imaging-assisted percutaneous techniques and blindly inserted by "Half-Perc" technique, the following search terms, including "Peritoneal Dialysis", "Percutaneous", "Catheter", ''laparoscopic", ''Fluoroscopic", ''Ureteroscopic", and ''Ultrasound", were used as keywords to identify all relevant studies.

The inclusion criteria were as follows: (1) patients were diagnosed as End-stage renal disease who need dialysis treatment, (2) those were performed peritoneal dialysis catheters inserted by the percutaneous technique with imaging-assisted methods, (3) the outcomes must evaluate one of the catheter-related complications, including infectious complications and mechanical complications as well as catheter survival, (4) and specific types of study were obtained, including randomized controlled studies, cohort studies (registries, historical prospective cohorts, retrospective cohorts), and non-comparative studies. Studies will exclude (1) review articles, (2) studies with the same sample, (3) and studies in pediatric patients. Finally, a total of 8 relevant studies were obtained that conformed to all of the eligible criteria.

Statistical analysis

Prism8 software (GraphPad Software Inc, La Jolla, CA) was used for statistical analyses. Normally distributed continuous variables were expressed as the mean ± standard deviation, quantitative data as the mean (or median) and range. Qualitative data were expressed as absolute numbers and percentages. The survival of PD catheter was estimated by Kaplan–Meier survival analysis. A p value < 0.05 was considered as statistically significant, and all tests were performed two-tailed.

Results

Baseline characteristics and operative parameters

Table 1 provides a summary of the baseline characteristics of patients included in this study. There were 174 men and 106 women, with a mean age of 50.4 years (range, 11–85 years). The mean operative time was 28.8 min (range, 15–38 min), and the incision length was 3.0 ± 0.8 cm. Analgesics were used in 51 patients (18.2%)

Table 1 Baseline characteristics of study population

Variables	"Half-Perc" ($N=280$)
Sex (male/female)	174/106
Age [mean (range), years]	50.4 (11–85)
BMI (kg/m^2)	
< 18.5	24 (8.6%)
18.5–23.9	136 (48.6%)
24–27.9	78 (27.8%)
≧ 28	42 (15.0%)
MAP (mmHg)	109.3 ± 16.0
Primary disease [*n* (%)]	
Glomerulonephritis	124 (44.3%)
Diabetic kidney disease	80 (28.6%)
Hypertensive nephropathy	13 (4.6%)
Obstructive nephropathy	10 (3.6%)
Other or unknown	53 (18.9%)
History of abdominal surgery [*n* (%)]	
Appendectomy	7 (2.5%)
Cesarean section	3 (1.1%)
Hysterectomy	3 (1.1%)
Herniorrhaphy	2 (0.7%)
Others	3 (2.1%)
Laboratory values	
Serum creatinine (μmol/L)	882.9 ± 280.1
Urea (mmol/L)	28.3 ± 10.9
Serum albumin (g/L)	34.7 ± 4.7
Hemoglobin (g/L)	78.3 ± 16.8
24 h urine volume (mL)	1060.0 ± 603.7
eGFR	5.5 ± 2.3
Duration of follow-up [mean (range), months]	15.4 (2–36)
Dialysis adequacy	
Total Kt/V urea	2.02 ± 0.49
Total Ccr (L/week/1.73·m2)	74.71 ± 27.52
D/P Cr (4 h)	0.69 ± 0.16

BMI Body mass index, *MAP* Mean arterial pressure, *eGFR* Estimated glomerular filtration rate, *Ccr* creatinine clearance, *D/P Cr* dialysate-to-plasma ratio of creatinine (D/P Cr)

within 24 h after the operation. The technical success rate was 99.3% (278/280), and the two unsuccessful cases were due to outflow failure after catheter insertion. These two cases were transferred to traditional open surgical placement during the operation. The median time between catheter placement and the start of regular PD was three days. Detailed operative parameters are summarized in Table 2.

Catheter-related complications

As shown in Table 3, 28 episodes of mechanical complications with initial catheters were observed in 28 patients

Table 2 Operative parameters

Variables	"Half-Perc" ($N=280$)
Operative time [mean (range), mins]	28.8 (15–38)
Incision length (cm)	3.0 ± 0.8
Bleeding volume (mL)	6.3 ± 2.3
Postoperative pain degree within 24 h	
No pain	33 (11.8%)
Mild pain	204 (72.9%)
Moderate pain	40 (14.3%)
Severe pain	3 (1.0%)
Usage of analgesics within 24 h	51 (18.2%)
Technical success rate	278 (99.3%)
Cost of surgery (CN¥)	1705.0 ± 1.8
Time to start PD [median (interquartile range), days]	3 (2–4)

(10%) during the follow-up period. Catheter malfunction was the most common mechanical complication observed in 15 patients (5.4%) who experienced 11 episodes (3.9%) of migration and four episodes (1.4%) of non-migration. Abdominal bleeding was the second most common mechanical complication, which appeared as slightly bloody ascites in six patients (2.1%). There were also two (0.7%) cases of dialysate leakage and five (1.8%) cases of hernias. There were 32 episodes of peritonitis observed in 29 (10.4%) patients, where three patients experienced peritonitis twice and two of them diagnosed with fungal peritonitis received catheter removal. Exit-site infections occurred in five patients.

Overall catheter survival and reason behind PD cessation

Patients were evaluated monthly for a mean follow-up period of 15.4 months (range, 2–36 months). At the end of the study, 235 patients (83.9%) survived with their initial PD catheter and were still undergoing PD. Figure 3 shows the Kaplan–Meier curves for overall catheter survival. The 1-, 2-, and 3-year survival rates were 88%, 82% and 79%. PD was ceased in 35 patients (12.5%) during the follow-up period (Table 4). Of these, 18 patients (6.4%) received successful renal transplantation. Nine (3.2%) patients died during follow-up, in most cases due to heart disease, and seven patients (2.5%) were transferred to HD due to inadequate dialysis and ultrafiltration failure. One patient (0.4%) voluntarily ceased PD due to renal failure recovery eight months after the procedure. Besides, a total of ten patients shifted to other PD centers during the follow-up due to distance from hospital or other reasons.

Table 3 Catheter-related complications over the follow-up period

Variables	Within 30 days (*N* = 280)	Beyond 30 days (*N* = 280)	During the follow-up (*N* = 280)
Mechanical complications	17 (6.1%)	11 (3.9%)	28 (10.0%)
Catheter malfunction	11 (3.9%)	4 (1.4%)	15 (5.4%)
Catheter migration	9 (3.2%)	2 (0.7%)	11 (3.9%)
Fibrin obstruction	1 (0.4%)	1 (0.4%)	6 (2.1%)
Omental wrapping	1 (0.4%)	1 (0.4%)	6 (2.1%)
Abdominal bleeding	4 (1.4%)	2 (0.7%)	6 (2.1%)
Dialysate leakage	1 (0.4%)	1 (0.4%)	2 (0.7%)
Exit-site	0 (0.0%)	1 (0.4%)	1 (0.4%)
Pleural	1 (0.4%)	0 (0.0%)	1 (0.4%)
Herniae	1 (0.4%)	4 (1.4%)	5 (1.8%)
Umbilical	1 (0.4%)	1 (0.4%)	2 (0.7%)
Inguinal	0 (0.0%)	3 (1.1%)	3 (1.1%)
Infectious complications	7 (2.5%)	26 (9.3%)	33 (11.8%)
Patients with peritonitis	5 (1.8%)	24 (8.6%)	29 (10.4%)
Episodes of peritonitis	5	27	32
Patients with exit-site infection	2 (0.7%)	2 (0.7%)	4 (1.4%)
Episodes of exit-site infection	2	3	5

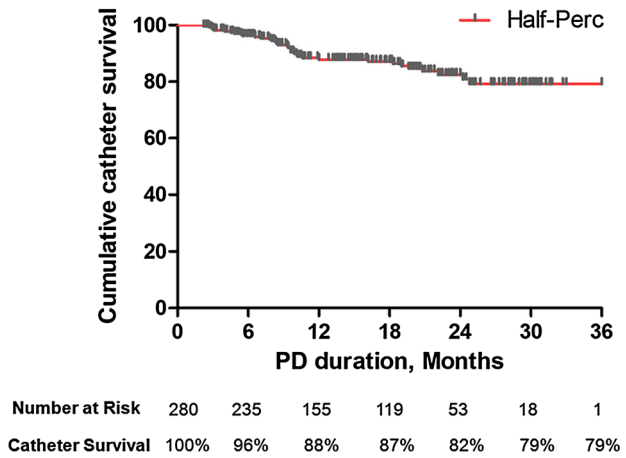

Fig. 3 Kaplan–Meier plot for overall catheter survival

Literature review

We performed a comprehensive literature review of studies of catheter-related complications using various percutaneous techniques assisted by fluoroscopy or ultrasound. Table 5 shows representative studies of double-cuffed catheter placement. Catheter-related complications associated with the "Half-Perc" technique with a modified metal trocar is comparable to rates reported in previous studies [17, 24–30].

Table 4 Reason behind PD cessation

Variables	"Half-Perc" (*N* = 280)
Patients (*n*%)	35 (12.5%)
Recovery of renal failure	1 (0.4%)
Renal transplantation	18 (6.4%)
Death	9 (3.2%)
Myocardial infarction	3 (1.1%)
Cardiac failure	1 (0.4%)
Sudden death	1 (0.4%)
PD-related peritonitis	1 (0.4%)
Influenza A (H1N1)	1 (0.4%)
Severe malnutrition	1 (0.4%)
Unknown	1 (0.4%)
Switch to HD	7 (2.5%)
Inadequate dialysis	2 (0.75)
Ultrafiltration failure	1 (0.4%)
Refractory fungal peritonitis	1 (0.4%)
Cognitive function disorder	1 (0.4%)
Bilateral inguinal hernia	1 (0.4%)
Patient preference	1 (0.4%)

PD peritoneal dialysis, *HD* Hemodialysis

Discussion

Zhu Bai et al. first introduced the "Half-Perc" technique using a special metal trocar in 2002 [18]. This new, modified percutaneous technique simplified the operation

Table 5 Previous and present studies using various imaging-assisted percutaneous technique for PD catheter placement

References	Design	Patients (n)	Follow-up (months)	History of abdominal surgery	Success rate (%)	Major modification	Catheter malfunction	Abdominal bleeding	Dialysate leakage	Herniae	Bowel/bladder perforation	Peritonitis	Exit-site / tunnel infection
Rosenthal [24]	Retrospective	52	12	None	Unknown	fluoroscopic guidance	8 (15.4%)	1 (1.9%)	2 (3.8%)	2 (3.8%)	None	11 (21.2)	13 (25.0%)
Voss [25]	Prospective	57	12	None	50 (87.7%)	fluoroscopic guidance	5 (8.8%)	None	5 (8.8%)	4 (7%)	1 (1.8%)	19 (33.3)	15 (26.3%)
Zhu [26]	Retrospective	47	2–36	4 (8.5%)	47 (100%)	ureteroscope-assisted	1 (2.1%)	4 (8.5%)	None	None	None	2 (4.3%)	None
Maher [27]	Retrospective	133	12	None	131 (98.5%)	Fluoroscopic guidance	26 (19.5%)	None	13 (9.8%)	12 (9.0%)	1 (0.8%)	44 (33.1)	57 (42.9%)
Al-Hwiesh [28]	Prospective	40	12	5 (12.5%)	39 (97.5%)	Fluoroscopic guidance	8 (20.0%)	None	1 (2.5%)	None	None	5 (12.5%)	2 (5.0%)
Diederick. [29]	Prospective	87	3–35	33 (34.5%)	87 (100%)	Ultrasound and fluoroscopy guidance	6 (6.9%)	None	1 (1.1%)	None	None	None	1 (1.1%)
Lee [17]	Retrospective	82	3	None	82 (100%)	Rectus muscle is penetrated by hemostat	4 (4.9%)	1 (1.2%)	6 (7.3%)	None	None	9 (11.0%)	5 (6.1%)
Li [30]	Retrospective	103	12	5 (4.8%)	101 (96.2%)	Ultrasound and bladder paracentesis trocar	5 (4.8%)	None	None	None	None	None	None
Present study	Retrospective	280	2–36	18 (6.4%)	278 (99.3%)	A modified metal trocar	15 (5.4%)	6 (2.1%)	2 (0.7%)	5 (1.8%)	None	29 (10.4%)	4 (1.4%)

process, only requiring local anesthesia and not requiring a peel-away sheath or assistance of ultrasound. This "Half-Perc" technique shares major advantages of both the Seldinger percutaneous technique and traditional open surgery, such as easy to perform by physicians, minimal tissue trauma, quick postoperative recovery, minimal lead time and lack of reliance on external specialties, and a relatively low incidence of catheter migration and dialysate leakage [20, 23]. Since the "Half-Perc" technique was performed in our PD center in 2015, we had indications of benefits related to its clinical efficacy.

In this study, all patients tolerated local anesthesia during the catheter insertion procedure. Only 51 patients (18.2%) needed analgesics within 24 h due to moderate or severe pain. Compared to other modified percutaneous catheter insertion methods [17, 26, 29], the operative time and duration from insertion to start of regular PD were relatively short. Although the time to start PD is judged based on the attending physician, a regular PD program must be started immediately after an operation to ensure the rescue of acute and critical cases [31]. We found no intestinal perforation risk even though this new technique is "blinded" without direct visualization of the abdominal cavity. We postulate that the rectus muscle dissected bluntly by a straight hemostat helps the rectus posterior sheath and parietal peritoneum expose clearly, and that the obvious empty sensation at the time of insertion of a sharp obturator within the central trocar by 1–2 mm into the peritoneal cavity contributes to protective effects against intra-abdominal visceral and vascular damages.

Catheter malfunction is the primary cause of PD technique failure, affecting long-term catheter survival [32, 33]. In this study, catheter malfunction was the most common mechanical complication observed, with 11 cases (3.9%) of catheter migration, two cases (0.7%) of fibrin obstruction and two cases (0.7%) of omental wrapping. However, catheter dysfunction was corrected in most of patients through traditional treatments. Two cases had catheter malfunction due to omental wrapping occurring on the fourteenth and thirty-fourth day, and received open surgery to correct catheter position. Omental wrapping was confirmed by traditional open surgery, and laparoscopy had not been used for catheter salvage in our present study. It is important to note that the 11 cases of catheter dysfunction were presented within 30 days post-surgery, suggesting that catheter dysfunction prevention should be given priority during the perioperative follow-up.

The incidence of other mechanical complications, such as abdominal bleeding, dialysate leakage, and hernias, was similar to or even lower compared to previous studies [17, 26, 28]. Six patients (2.1%) had slightly bloody ascites, which temporarily appeared in the first bag of PD drainage fluid each day and lasted for an average of three days (range, 1–7 days). Patients did not have persistent bleeding, nor a significant decline in hemoglobin during follow-up, except one patient who showed slightly bloody ascites from the third day to the sixth month after catheter insertion due to gynecological diseases. Dialysate leakage occurred in only two cases (0.7%), including one case of exit-site leakage and another of pleural leakage at eight months and four weeks after surgery, respectively. However, many studies report catheter leakage with a rate of 3.8–9.8% [17, 24, 25, 28], even when using the new percutaneous technology in which early leakage incidence reached 2.5% (1/40) [27]. In this study, despite 7 patients (2.5%) initiating a PD program immediately after catheter insertion and 80 cases (28.6%) commencing a regular PD program within two days, the prevalence of dialysate leakage was low. This was probably due to the smaller incision, and a purse-string suture in the anterior rectus sheath, and the rectus muscle's blunt dissection, which avoids unnecessary injury to the rectus muscle and contributes to a low leakage rate.

Infectious complications of PD operation include peritonitis and exit-site or tunnel infections, which can lead to technical failure or even death [34]. Many studies suggest that the prevention of peritonitis is necessary to increase catheter survival and PD's long-term success [35]. Earlier studies showed that the incidence of peritonitis after PD is 4.3–33.1% [17, 26–28]. The diversity of results found in the literature may result from various PD catheter insertion methods and different follow-up periods. In this study, there were 32 episodes of peritonitis observed in 29 (10.4%) patients. Most peritonitis cases were successfully treated with antibiotics, except for two patients with fungal peritonitis occurring in the fifth and eighth month, who underwent catheter removal. Only four patients developed exit-site infections, experiencing five episodes (1.8%). However, according to recent PD access guidelines, PD catheter-related infections may have non-surgical effects beyond 30 days after catheter insertion. In addition, peritonitis and exit-site/tunnel infection rates within 30 days of catheter insertion should be lower than 5% [7]. This study reported only five cases (1.8%) of peritonitis and two cases (0.7%) of exit-site infections within 30 days.

Conclusion

The “Half-Perc” technique is a simple, safe, and effective method for PD catheter insertion in patients with ESRD and may serve as an alternative to achieve comparable or more optimal clinical efficacy than other imaging-assisted percutaneous techniques during a long follow-up period. However, this technique should be evaluated in multi-center prospective cohort studies or randomized controlled trials.

Declarations

Conflict of interest This manuscript has been reviewed and approved by all of the authors, and no results reported in this manuscript have been published elsewhere. All authors declare that there are no conflicts of interest.

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