



# A half-percutaneous technique for peritoneal dialysis catheter implantation using a modified trocar: a report of 84 cases

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## Abstract

**Purpose** Peritoneal dialysis (PD) catheter implantation is necessary for patients with end-stage renal disease (ESRD) to maintain continuous ambulatory PD (CAPD). In this study, we aimed to introduce a half-percutaneous technique based on a modified trocar device for the placement of a PD catheter and to evaluate the safety and efficacy of this technique and its associated short-term postoperative outcomes.

**Methods** Eighty-four ESRD patients who underwent PD catheter implantation with the half-percutaneous technique were recruited retrospectively between September 2016 and October 2017 from the Guangdong Provincial Hospital of Chinese Medicine. All catheter implantation procedures were performed by the same three nephrologists. The surgical protocol was described in detail, and the general intraoperative parameters and short-term complications were evaluated.

**Results** All ESRD patients underwent successful PD catheterization with our novel technique. Neither conversion from this method to traditional open surgery nor major intraoperative complications were observed. The mean operative time was  $20.8 \pm 4.5$  min, and the incision length was  $2.28 \pm 0.53$  cm. The operative cost was CN ¥ 1762.45 (US \$261), and the length of hospital stay was  $7.5 \pm 0.58$  days. One patient (1.19%) showed leakage, and one patient (1.19%) experienced bleeding 2 weeks after the surgery. Catheter dysfunction due to catheter tip migration occurred in nine patients (10.7%) 2 weeks after the procedure, and the placement of the catheter was corrected with conservative treatment. No visceral injuries or PD-related infections were observed up to 4 weeks after the catheters were implanted.

**Conclusions** This half-percutaneous technique for PD catheter implantation appears to be a safe, effective and feasible procedure. This technique has the advantages of reduced surgical trauma, a shorter operative time and faster postsurgical recovery. In particular, this novel technique is easy for nephrologists to perform and therefore may help to promote and popularize PD treatment.

**Keywords** Peritoneal dialysis · PD catheter implantation · Modified trocar · Half-percutaneous technique · Short-term outcomes

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## Introduction

Chronic kidney disease (CKD) has become a major public health problem for the Chinese government [1]. According to the data from recent epidemiological investigations in China, the overall prevalence of CKD is approximately 10.8%; therefore, there are almost 120 million patients with CKD in China [2]. Among these patients, end-stage renal disease (ESRD) occurs in 207 per million people in China [3], and the number of new cases of ESRD every year is estimated to reach approximately 260,000 by 2020. ESRD patients eventually require renal replacement therapy, such as haemodialysis (HD) and peritoneal dialysis (PD).

In recent years, PD has been regarded as a well-accepted dialysis modality owing to several benefits: this modality is less expensive than in-centre HD, is easy to perform and can be used for home dialysis [4].

The success of PD depends on the placement of a well-functioning and durable peritoneal catheter. Therefore, a suitable peritoneal catheterization technique plays a crucial role in initiating and maintaining PD for patients with ESRD. The catheter placement methods used mainly include traditional open surgery, a percutaneous needle-guidewire technique, a peritoneoscopic procedure, and surgical laparoscopy [5]. Some data have indicated that only a small proportion of PD catheterization procedures were performed by nephrologists in the past decade, and most PD catheters were implanted by surgeons in many PD centres [6], suggesting that the peritoneal catheter implantation technique has become an important factor for limiting the spread and development of PD and that establishing a simpler and more feasible technique that is easy for nephrologists to master is urgently needed.

The purpose of the present study was to share our experience with PD catheterization using a novel optimized percutaneous technique and to evaluate the safety, efficacy, and short-term outcomes of this method for PD catheter placement.

## Materials and methods

### Patients

We retrospectively enrolled 84 patients diagnosed with ESRD at the Guangdong Provincial Hospital of Chinese Medicine from September 20, 2016, to October 27, 2017,

according to the 2012 Kidney Disease Improving Global Outcomes (KDIGO) guidelines. All patients underwent PD catheter placement with a half-percutaneous technique, and a standard Tenckhoff catheter was used in this study.

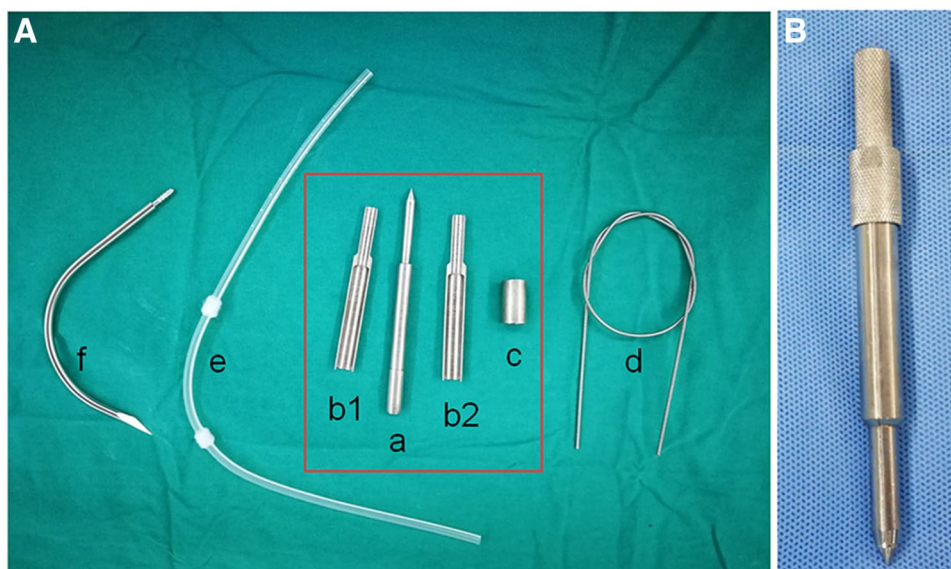
### Variables and outcomes

Data were collected for variables including demographic features, primary diseases, the operative time (the time between the beginning and end of the procedure, excluding the anaesthesia time), the incision length, the surgery cost and the length of hospital stay. Short-term postoperative complications, such as leakage, bleeding, catheter dysfunction and peritonitis, were analysed within 1 month postoperatively. As a baseline cost, the cost of traditional open surgery for catheter placement in Guangzhou was determined to be approximately CN ¥ 2254 RMB (US \$333.83).

### Surgical procedure

All patients were administered 1% lidocaine for local anaesthesia. The half-percutaneous technique for peritoneal catheterization was performed using a modified trocar (Patent no. 02273526.7), which mainly consists of one core needle, a two-part trocar and one hoop (Fig. 1). The novel optimized method was performed according to the procedure described below. We made a 2-cm paramedian incision either 1–2 cm inferior to the umbilicus or 10–12 cm above the pubic symphysis, followed by blunt dissection of the subcutaneous tissue with a haemostat. A small incision ~ 0.5 cm long was made in the anterior layer of the rectus sheath, and a purse-string suture was placed around the incision but temporarily not tightened. The rectus muscle was dissected bluntly with a haemostat, and the posterior layer of the rectus sheath

**Fig. 1** The main components of equipment for catheter implantation. **A** The structure of modified trocar and other important materials. (a) Core needle. (b) Trocar, including two independent parts. (c) Hoop. (d) Guide-wire. (e) Tenckhoff catheter. (f) Tunnel needle. **B** Configuration of the modified trocar for the rectangular region in **A**



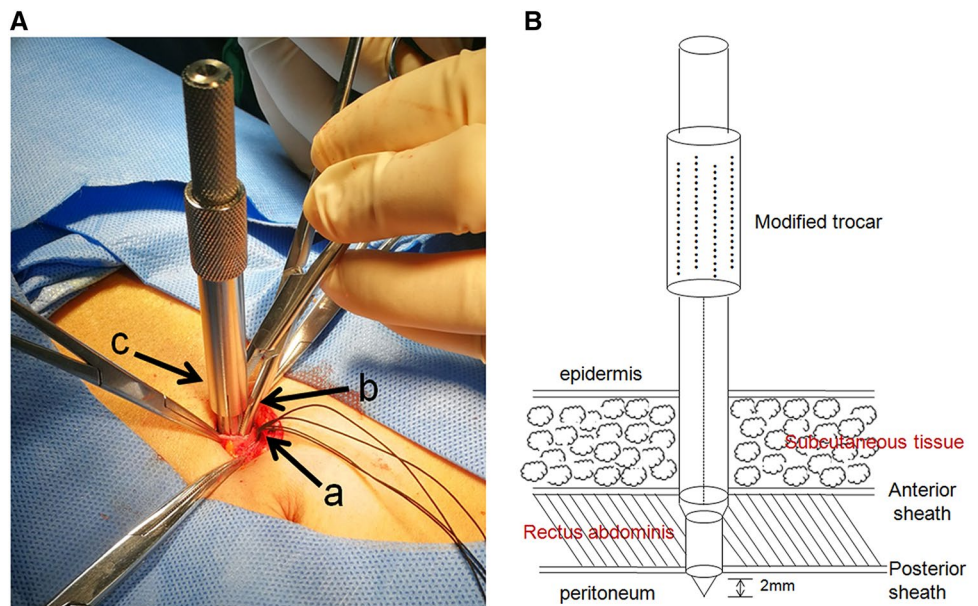
and parietal peritoneum was punctured directly using the modified trocar device (Fig. 2). The operator should stop this procedure once an obvious empty sensation is felt. A reusable guidewire (60 cm long and 2 mm thick) was vertically inserted ~ 5 cm into the peritoneal cavity through the hollow trocar after the core needle was removed. The peritoneal catheter was then inserted through the trocar guided along the guidewire. The angle of the trocar was adjusted to direct it towards the pelvic cavity. The catheter was threaded along the guidewire until it reached the right or left pelvic gutter (Fig. 3). The guidewire was then removed. To verify the correct positioning of the implanted PD catheter, the peritoneal cavity was rapidly injected with 50 ml of warm saline several times, and we observed that the fluid flowed out quickly through the catheter. In addition, we asked the patients about their perceptions to ensure that they had strong sensations of

needing to urinate and defecate. The deep cuff was secured in the rectus muscle using sutures fixed at the peritoneal entry site and in the outer rectus sheath. A subcutaneous tunnel tract was fashioned at the upper and outer edge of the primary incision with a tunnel needle, and the PD catheter was pulled out through the exit site (Fig. 4). To confirm that the PD catheter was unobstructed and that there was no intra-abdominal bleeding, the catheter was flushed several times with a total of 200 ml of PD solution. Regular full PD was initiated soon after surgery among patients who needed acute dialysis.

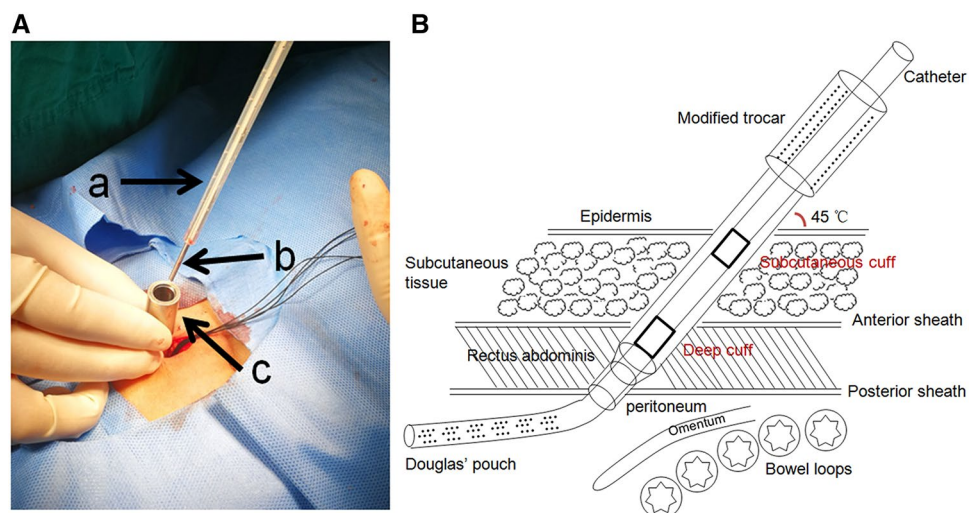
**Statistical and analysis**

The statistical analysis was performed using SPSS Statistical Package version 20.0. Descriptive statistics were used and

**Fig. 2** Abdominal tissue dissection and trocar puncture. **A** The outside view of the abdominal wall procedure. (a) A purse-string suture on the anterior rectus sheath. (b) Blunt dissection of rectus abdominis with a haemostat. (c) Vertical puncture of trocar. **B** Schematic of trocar puncture in the peritoneal cavity at the indicated site



**Fig. 3** PD catheter insertion. **A** The outside view of peritoneal catheter insertion under the guiding wire. (a) Catheter. (b) Guidewire. (c) Hollow trocar. **B** Schematic of catheter implantation showing its proper relationship to adjacent anatomic structures







**Fig. 4** The outline drawing of the catheter after operation

are expressed as the mean and standard deviation, range, and numbers and percentages.  $P < 0.05$  was considered statistically significant.

## Results

### Patient characteristics

This study enrolled 84 patients with ESRD who were dependent on renal replacement therapy between January 2015 and October 2017. There were 50 (59.5%) men and 34 (40.5%) women, with a mean age of  $52.3 \pm 15$  years (range 18–91 years). In our study, chronic nephritic syndrome was the most common cause of ESRD, followed by diabetic nephropathy and hypertensive nephropathy. The demographic and baseline clinical data are summarized in Table 1.

### Hospitalization and intraoperative parameters

All patients underwent successful PD catheter implantation with a half-percutaneous method. Neither conversion from this method to traditional open surgery nor major intraoperative complications, including massive haemorrhage, severe pain and unnecessary trauma to other organs, were observed. The mean operative time was  $20 \pm 4.5$  min. The incision length was  $2.28 \pm 0.53$  cm. The mean intraoperative bleeding volume was 10.3 ml. The operative cost was CN ¥ 1762.45 (US \$261). The length of postoperative stay was  $7.5 \pm 0.58$  days. The hospitalization and intraoperative parameters are shown in Table 2.

**Table 1** Demographic and clinical characteristics

Characteristics	Number ( $n=84$ )
Mean age (years)	$52.3 \pm 15.0$
Sex (male/female)	50/34
BMI ( $\text{kg}/\text{m}^2$ )	$23.58 \pm 4.22$
Primary disease	
Chronic nephritic syndrome	31
Type 2 diabetic nephropathy	24
Hypertensive nephropathy	13
Obstructive nephropathy	4
Other causes	12
History of abdominal surgery	6 (7.1%)
First catheterization	84 (100%)
Medication prescription	
ACEI/ARB	55 (65.47%)
Erythropoiesis stimulating agents	76 (90.47%)
Oral anticoagulants	0
Laboratory values	
Serum creatinine [ $\mu\text{mol}/\text{L}$ mean/SD]	$945.6 \pm 296.9$
Blood urea nitrogen [ $\text{mmol}/\text{L}$ mean/SD]	$30.21 \pm 10.86$
Glomerular filtration rate [(%) mean/SD]	$5.14 \pm 2.41$
Serum albumin (g/L)	$35.01 \pm 3.25$
Haemoglobin (g/L)	$81.81 \pm 16.77$
24 h urine volume (L)	$1074 \pm 595.09$

### Short-term postsurgical outcomes

The number of patients using analgesics within 24 h and 48 h after catheter implantation was 7 (8.33%) and 3 (3.57%), respectively. Among the short-term postsurgical complications, catheter dysfunction was the most common, occurring in 9 of the 84 patients (10.71%) within 2 weeks, as shown in Table 3. One patient (1.19%) showed dialysate leakage, and one patient (1.19%) showed bloody dialysate 2 weeks later. There were no incidences of inadvertent injury to visceral organs or catheter-related infections, such as peritonitis, exit site or tunnel infections, for up to 1 month.

**Table 2** Hospital and operative parameters

Variables	Number ( $n=84$ )
Operative cost (CN ¥)	1762.45 (US \$261)
Hospital stay (days)	$7.5 \pm 0.58$
Operative time (mins)	$20.8 \pm 4.5$
Incision size (cm)	$2.28 \pm 0.53$
Bleeding volume (ml)	$10.3 \pm 2.5$

**Table 3** Early postoperative complications

Postoperative complications	Number ( <i>n</i> = 84)
Use of analgesic within 24 h [ <i>n</i> (%)]	7 (8.33)
Use of analgesic within 48 h [ <i>n</i> (%)]	3 (3.57)
Leakage in 2 weeks [ <i>n</i> (%)]	1 (1.19)
Bloody dialysate in 2 weeks [ <i>n</i> (%)]	1 (1.19)
Catheter dysfunction in 2 weeks [ <i>n</i> (%)]	9 (0.71)
Visceral injury in 4 weeks [ <i>n</i> (%)]	0
Exit and tunnel infection in 4 weeks [ <i>n</i> (%)]	0
Peritonitis in 4 weeks [ <i>n</i> (%)]	0

## Discussion

An optimal technique for catheter placement should minimize the incidence of catheter-related complications and be relatively easy for nephrologists to master. In this study, we aimed to introduce a simple and feasible method for PD catheter insertion using a half-percutaneous method. This new technique achieved a low incidence of intraoperative complications and an improved early postoperative outcome.

Traditional surgery can cause considerable mechanical trauma, and postoperative catheter displacement remains a major issue in clinical practice. Percutaneous peritoneal catheter insertion with or without imaging guidance is not commonly performed because the materials and equipment required are relatively expensive, and inadvertent injury to the bowel and urinary bladder may occur during catheter insertion due to the sharp and thin needle tip [7]. The peritoneoscopic approach [8] and laparoscopic approaches for peritoneal catheter implantation have been widely adopted in recent years, because these techniques are minimally invasive and allow comprehensive visualization of the peritoneal cavity [9]. The advantage of surgical laparoscopy for catheter placement is that this technique can achieve significantly improved catheterization outcomes owing to accurate positioning and a smaller incision, among other factors. However, the clinical application of both the peritoneoscopic approach and surgical laparoscopy has been limited, likely due to the relatively high hospitalization cost and difficulty for physicians to master laparoscopy.

To overcome these issues, we created a new and simple technique for PD catheterization using a metal trocar, which is partially different from the percutaneous technique. Therefore, we call this technique a half-percutaneous technique. There are many differences between this technique and the Seldinger technique. First, different from the Seldinger percutaneous technique, blunt dissection of the rectus muscle is performed with a haemostat instead of direct puncture of the rectus muscle with a trocar to prevent injury to vessels and bleeding of the rectus muscle. Second, the posterior layer of the rectus sheath

and the parietal peritoneum are punctured directly using the modified trocar device, and the obvious empty sensation that is felt during the procedure reduces the risk of intra-abdominal visceral and vascular injuries. Third, the deep cuff is secured within the rectus muscle using sutures placed in the anterior layer of the rectus sheath and in the outer rectus sheath, which could be helpful for preventing dialysate leakage.

In addition, this new method makes the procedure for PD catheter placement simpler and easier than that of other approaches, including the Seldinger percutaneous technique, traditional open surgery and surgical laparoscopy techniques. This procedure can be performed with relatively little trauma and bleeding, which is useful for reducing mechanical injury and promoting postoperative recovery. Relatively little equipment is required for PD catheterization using this technique, and this approach is relatively easy for nephrologists to perform. Furthermore, the devices, such as metal trocars and guidewires, can be reused, and the procedure is therefore more cost-effective. This procedure may be suitable for promotion in remote and underdeveloped regions lacking sufficient medical and economic resources.

Usually, PD catheter implantation can be performed as a day care procedure or with a minimum of 1–2 days of hospitalization. However, the average hospitalization time was 7.5 days in this study. Perhaps, we shall consider that although the operative cost was CN ¥ 1762.45 (US \$261), the prolonged hospital stay would increase the cost. In fact, while the PD catheter placement could be performed within 1 or 2 days at our PD centre, most of the ESRD patients required urgent treatment when they came to the hospital, likely due to severe heart failure, pulmonary oedema, severe hyperkalaemia or gastrointestinal symptoms, among other causes. Therefore, 1 or 2 days were required to evaluate the situation of each patient before PD catheter placement. In addition, most patients immediately initiated regular peritoneal dialysis once the PD catheter was inserted using the half-percutaneous technique, so they needed to receive operational training at the peritoneal dialysis centre for several days. Therefore, while the average length of hospital stay was relatively long, the increased cost was necessary.

Peritoneal catheter insertion can be associated with several important procedural complications. Bleeding is a relatively common complication after peritoneal catheter insertion, although severe bleeding occurs in only 1–5% of procedures [10]. Relatively mild, but frequent intra-abdominal bleeding associated with blood-stained effluent is commonly associated with Tenckhoff catheters due to the need for an extra incision after surgery [11]. In the current study, only one (1.19%) patient experienced bleeding within 2 weeks postoperatively. We speculate that the reason for the low incidence of postoperative bleeding was that the modified trocar requires a small incision wound, which decreases

vascular injury owing to the midline incision in the tensed rectus abdominis.

There are still conflicting results reported in the literature concerning the frequency of dialysate leakage, likely due to the different types of peritoneal catheterization used and the diverse follow-up periods in the literature [12]. A previous study reported the frequency to be as high as 12.8% [13]. Dialysate leakage usually occurs in the first few weeks after PD catheter implantation and is more obvious because patients are free to move. In our study, only 1 (1.19%) case of catheter leakage was observed within 2 weeks. Our surgical technique might be helpful for keeping the peritoneal catheter fixed firmly to the tight posterior rectus sheath and peritoneum and the deep cuff fixed to the strong contractile rectus abdominis.

Catheter malfunction is a common complication of PD that can result from catheter migration, tube kinking, bowel trapping, omental wrapping, blood clots or fibrin, obstruction secondary to intraperitoneal adhesions or infection [14]. Previous research has shown that catheter migration occurs in 12% of patients undergoing open surgery [15] and that catheter tip migration and omental entrapment occur in 1.7% and 2.9% of patients, respectively [16]. In our study, catheter dysfunction originating from catheter tip migration occurred in nine patients (10.7%) 2 weeks after PD insertion, which is a relatively high rate within a short-term postoperative follow-up period. However, catheter migration in all of these patients was corrected in time through conservative treatments, such as promoting intestinal emptying and climbing up and down stairs. Ultimately, no patient required surgical intervention, suggesting that this modified percutaneous method could ensure successful catheter access. In addition, no catheter-related infections were observed up to 4 weeks after surgery.

Inadvertent injury to visceral organs, including the small bowel, large bowel and urinary bladder, usually occurs during entry into the abdominal cavity or due to placement of the peritoneal catheter tip in the lower abdomen [7]. No cases of perforation of the small or large intestine were observed in our study. According to a previous study, the percutaneous implantation of catheters involving puncture of the peritoneal cavity using a trocar device rarely leads to visceral injury [17]. Our study and others have shown that a well-planned percutaneous technique may not require visualization of the peritoneal cavity during placement of a PD catheter.

Another advantage of this new technique for catheterization is that it is helpful for emergent rescue in critically ill patients in the late stages of uraemia because regular dialysis can be performed immediately after surgery. For example, patients with massive ascites suffering from polycystic kidney disease, malignant tumours and severe obesity require urgent treatment, and these patients can receive

timely treatment with this modified technique for catheter implantation.

## Conclusion

The results of the current study indicate that our half-percutaneous technique is a safe, effective and feasible method for peritoneal catheter insertion, which suggests that it may be a good option for inserting peritoneal catheters for PD patients and an accessible method for nephrologists to perform. However, studies with longer-term follow-up periods and larger sample sizes are needed, and the reliability of this technique still needs to be confirmed by prospective studies or randomized controlled trials.

## Compliance with ethical standards

**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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