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NEPHROLOGY - ORIGINAL PAPER

A simple modified open peritoneal dialysis catheter insertion procedure reduces the need for secondary surgery

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Abstract

Background The aim of this retrospective study was to assess the efficacy of a modified peritoneal dialysis catheter insertion technique for reducing the incidence of mechanical complications.

Methods We conducted a retrospective analysis of clinical data of 346 patients undergoing peritoneal dialysis catheter insertion at our peritoneal dialysis center. The traditional procedure was performed in 157 patients (group A) and the modified procedure in 189 patients (group B). The double-polyester-cuff straight Tenckhoff catheter was used in all patients.

Results At the end of 1 year, tunnel inflammation was more common in group A (21 patients after 0.011 patient-months follow-up versus 10 patients in group B after 0.007 patient-months of follow-up; $p=0.009$). Technical survival rate of the catheter was significantly higher in group B (97.35% in group B vs. 89.81% in group A; $p=0.005$). All-cause mortality was not significantly different between the two groups (4.5% in group A vs. 3.2% in group B; $p=0.532$). Postoperative mechanical complications were also higher in group A (32 patients [20.4%] in group A vs. 3 patients [1.6%] in group B; $p<0.001$). The incidences of complications such as hernia, dialysis fluid leakage, hemorrhage, incision infection, and prolapse of the polyester cuff were similar in the two groups.

Conclusion The simple modified peritoneal dialysis catheter insertion procedure decreases the occurrence of catheter migration andomental encapsulation and improves the technical survival rate of the catheter.

Keywords Catheter · Chronic renal failure · Mechanical complication · Peritoneal dialysis

Introduction

Peritoneal dialysis is an important and widely used form of renal replacement therapy in chronic renal failure patients. Mechanical complications such as catheter migration and omental encapsulation are common in peritoneal dialysis, occurring in 5.2–31% of patients [1–3]. They are particularly common in centers without much experience in peritoneal dialysis. Mechanical complications increase medical costs and reduce patient confidence in peritoneal dialysis. Furthermore, the need for re-operation increases the psychological stress and the physical pain of patients. Nephrologists, the world over, have been searching for ways to reduce the incidence of such complications. At our peritoneal dialysis center, where we have accumulated many years of experience, a series of improvements have been made to the traditional peritoneal dialysis catheter insertion surgery in an attempt to reduce the incidence of mechanical complications and improve the survival rate of the catheter. In this retrospective study, we describe the modified procedure

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and examine its effectiveness in reducing the incidence of mechanical complications.

Methods

Patients

From February 2007 to January 2017, 346 patients had double-cuff straight Tenckhoff catheter (Covidien, Mansfield, MA, 02048, USA) insertion performed at our center for peritoneal dialysis. Thetotal length of this catheter is 41 cm and the intraperitoneal segment length from the catheter tip to the edge of the inner cuff is 15 cm. All patients had clear indications for renal replacement therapy and no contraindications for peritoneal dialysis. Patients with difficult abdomen due to prior surgery were excluded. Of the 346 patients, 157 patients (group A) received traditional open surgery from February 2007 to June 2011, and 189 patients (group B) underwent the modified surgical procedure between July 2011 and January 2017. The operations in both groups were performed by different teams, with each team comprisingan expert in the procedure, a resident, and an intern.

This study was approved by the Regional Ethics Committee of our hospital and all patients signed informed consent. All procedures were in accordance with the tenets of the Declaration of Helsinki.

Traditional surgery

Surgery was performed under subarachnoid anesthesia. Patients were asked to empty their bladder before surgery, and the upper edge of the pubic symphysis was marked. The catheter was inserted in the anterior abdominal wall, 12 cm above the pubic symphysis and 2.5 cm to the right of the midline. After routine disinfection, a longitudinal 3–5 cm incision was made, with the catheter insertion site as the midpoint. Subcutaneous tissue was separated, and the anterior rectus sheath was dissected; blunt separation of the rectus abdominis was then performed to expose the posterior rectus sheath. The posterior rectus sheath and peritoneum were clamped together and were purse-string sutured. A 1 cm incision was made at the middle of the purse and the catheter tip, guided by a stainless steel wire, was placed in the Douglas fossa. The purse-string suture on the peritoneum was then ligated at the lower edge of the inner cuff, ensuring that the inner cuff was kept outside of the peritoneal cavity. After confirming the smooth inflow and outflow of normal saline, the anterior rectus sheath was closed with intermittent sutures, with the proximal end of the inner cuff embedded in the rectus abdominis, and the catheter piercing through the middle of the incision in the sheath. The part of the catheter outside of the abdomen was directed towards the head of the patient and kept close to the abdominal wall during the whole process. After once again confirming smooth inflow and outflow of normal saline, the tunnel needle was used to direct the Tenckhoff catheter through the skin and subcutaneous fat, with the needle tip pointed toward the lower right side of the patient during the piercing; care was taken to keep the outer cuff around 2.5 cm from the exit site on the abdominal wall.

Modified peritoneal dialysis catheter insertion

In brief, surgery was also performedunder subarachnoid anesthesia. An incision was made and subcutaneous tissue was separated. After the anterior rectus sheath was dissectedand, the rectus abdominis separated, the posterior rectus sheath and peritoneum were purse-string sutured. Guided by a stainless steel wire, the catheter tip was placed in the flank of the Douglas fossa through the incision at the purse. Then, the distal part of the catheter was fixed onto the peritoneum of the lateral abdominal wall with a suture, and the purse-string suture on the peritoneum was ligated (Fig. 1). After confirming the catheter was unobstructed, the anterior rectus sheath was closed with the catheter piercing through the upper end of the incision in the sheath. The remaining procedures were performed as mentioned above.

The salient features of the modified peritoneal dialysis catheter surgery are: (1) The catheter is inserted 9 cm(female patients) or 11 cm(male patients) from the upper edge of the pubic symphysis, 2.5 cm to the right of the midline; (2) the catheter end is advanced and placed in the flank of the Douglas fossa; (3) the inner polyester cuff and the distal catheter are embedded in the rectus abdominis muscle; the catheter exits at the upper end of the incision in the anterior rectus sheath;and (4) the catheter is fixed onto the peritoneum of the lateral abdominal wall with a suture.

Postoperative peritoneal dialysis management

According to the unified plan, 500 ml/time Q1h $\times$ 2 bags was used on days 1–2 after surgery; 666 ml/time Q2h $\times$ 3 bags on days 3–5; 1000 ml/time Q2h $\times$ 3 bags on days 6–8; 1500 ml/time Q3h $\times$ 3 bags on days 9–11;, and 2000 ml/time Q4h $\times$ 3–4 bags from day 12 onwards.

Statistical analysis

Data were expressed as mean $\pm$ standard deviation or as percentages. The *t* test and the Chi square test were used, as relevant, for comparisons between groups. $p \leq 0.05$ was considered statistically significant. Statistical analysis was performed using SPSS 17.0 software (SPSS Inc., Chicago, IL, USA).

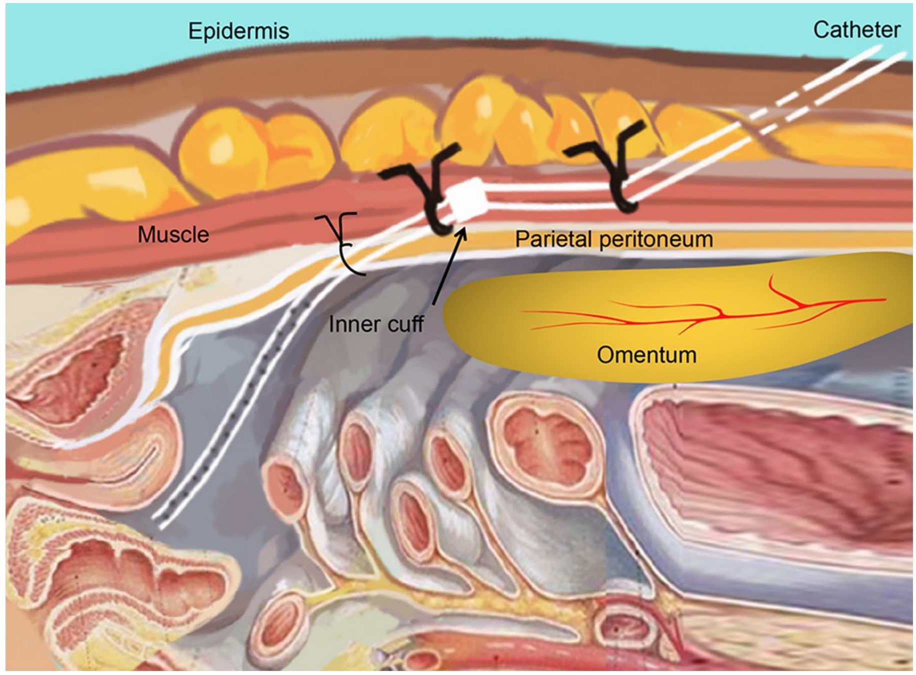

Fig. 1 Schematic of a Tenckhoff catheter showing its relationship to adjacent anatomic structures. The upper 3-cm section of the catheter adjacent to inner cuff is embedded in the rectus abdominis muscle; the catheter in the abdomen is immobilized by fixationto the parietal peritoneum

Results

Patient characteristics

A total of 346 patients (152 men and 194 women; mean age, 52.9 ± 15.2 years) were enrolled in the study. The primary disease was glomerulonephritis in 114 patients, obstructive nephropathy in 77 patients, hypertension in 63 patients, diabetic nephropathy in 39 patients, polycystic kidney in 28 patients, and other diseases in 25 patients. There were no significant differences between the two groups in mean age, gender ratio, and primary disease (Table 1).

Identification of the optimal catheter insertion site

The distance between the pubic symphysis and the Douglas fossa was measured in a randomly selected sample of 60 (30 male and 30 female) patients. At a follow-up visit,these patients underwent abdominal plain CT with three-dimensional reconstruction. On the median sagittal image, the theoretical optimal catheter insertion site was marked; this was identified by starting from the Douglas fossa and measuring out 15 cm along the abdomen wall. The distance from this optimal site to the pubic symphysis was recorded (Fig. 2a, b; Table 2).

Table 1 Clinical characteristics and 1-year follow-up data of patients

Variable	Patient group		
	Traditional surgery group (A)	Modified surgery group (B)	*p* value
Patients (*n*)	157	189	NA
Age (years)	51.6 ± 13.1	52.5 ± 14.8	0.874
Sex (*n*;male:female)	68:89	83:106	0.913
Primary disease [*n* (%)]			
Glomerulonephritis	53(33.8%)	61(32.3%)	0.770
Obstructive nephropathy	32(20.4%)	45(23.8%)	0.445
Hypertension	28(17.8%)	35(18.5%)	0.870
Diabetic nephropathy	19(12.1%)	20(10.6%)	0.656
Polycystic kidney	13(8.3%)	15(7.9%)	0.907
Other causes	12(7.6%)	13(6.9%)	0.784
Infective complications			
Peritonitis episodes	23	30	0.753
Episodes/patient-month	0.012	0.013	0.753
Tunnel inflammation episodes	21	10	0.009
Episodes/patient-month	0.011	0.007	0.009
Initial catheter survival [*n* (%)]	141 (89.81%)	184 (97.35%)	0.005
Overall deaths [*n* (%)]	7 (4.5%)	6 (3.2%)	0.532

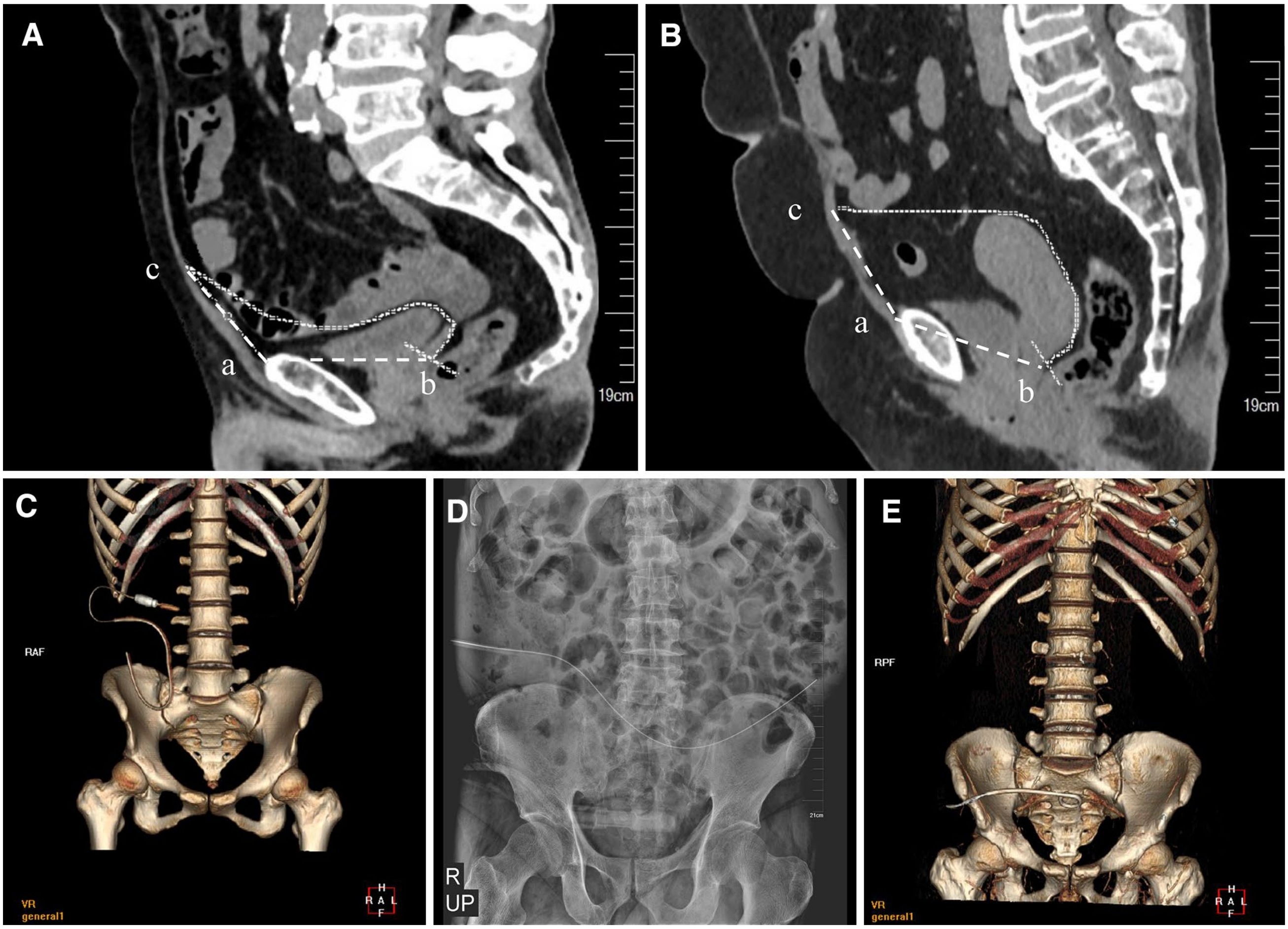

Fig. 2 The optimal catheter insertion site and the common locations of the catheter tip after catheter migration in peritoneal dialysis. Distance from the pubic symphysis to the Douglas fossa (ab), and distance from the pubic symphysis to the optimal insertion site (ac) measured on **a** midline sagittal CT screenshot of a male patient and **b** midline sagittal CT screenshot of a female patient. **c** The straight Tenckhoff catheter is bent backwards and to the right and the tip is above the pelvic cavity; **d** the straight Tenckhoff catheter has migrated to the left side, with the end above the pelvis; **e** the straight Tenckhoff catheter is curled and the tip has migrated to the central pelvis

Table 2 Distances from the symphysis pubis to Douglas fossa and the optimal catheter insertion site

Variable	Patient group		
	Male	Female	*p* value
Patients (*n*)	30	30	
Distance from symphysis pubis to Douglas fossa (ab)	11.94 ± 0.76	12.81 ± 0.61*	< 0.001
Distance from symphysis pubis to the optimal catheter insertion site (ac)	11.0 ± 0.92	9.03 ± 0.65*	< 0.001

*Statistically significant difference between the two groups

Comparison of the two surgical procedures

Peritonitis

The incidence of peritoneal dialysis-associated peritonitis was not significantly different between the two groups (23 patients in group A after 0.012 patient-months of follow-up vs. 30 patients in group B after 0.013 patient-months of follow-up; $p = 0.753$; Table 1).

Tunnel inflammation

At the end of 1 year, the incidence of tunnel inflammation was significantly higher in group A (21 patients in group A after 0.011 patient-months of follow-up vs. 10 patients in group B after 0.007 patient-months of follow-up; $p=0.009$).

Technical survival rate of catheter

At the end of the 1-year follow-up, the technical survival rate ofthe catheter was significantly higher in group B (97.35% in group B vs. 89.81% in group A; $p=0.005$).

All-cause mortality

All-cause mortality was slightly higher in group A after 1 year of follow-up (4.5% in group A vs. 3.2% in group B; $p=0.532$) but the difference was not statistically significant.

Postoperative mechanical complications

Mechanical complications (catheter migration, catheter obstruction, or omental encapsulation) were seen in 32/157 (20.4%) patients in group A versus 3/189 patients (1.6%) in group B. In group B, one case of catheter migration was restored to normal by manipulation of the catheter, and two cases of fibrin clogging of the catheter were treated successfully with fibrinolytic drugs. During the 1-year follow-up, polyester cuff prolapse occurred in 7/157 (4.5%) patients in group A and in 8/189 (4.2%) patients in group B; the difference was not statistically significant ($p=0.918$; Table 3).

Other complications

The incidence of other complications, such as hernia, dialysis fluid leakage, and discomfort associated with dialysate inflow and outflow, hemorrhage, chylous peritoneal dialysis, and incision infection was similar in the two groups.

Peritoneal dialysis catheter migration

Catheter migration affects the drainage of peritoneal dialysis fluid. It usually occurs within 1 week after surgery, and is rare after 3 months. Figure 2c–e shows the common positions of the catheter after displacement. If the tip of the catheter is above the pelvis, complete drainage of peritoneal dialysis fluid will not be possible.

Position of the peritoneal dialysis catheter in the abdominal cavity

The location of the peritoneal dialysis catheters in the two groups was observed and compared using CT three-dimensional reconstruction. In group B, the catheter tip was in the most dependable position in the pelvic cavity—the Douglas fossa (Fig. 3); the location of the catheter tip in group A was generally higher.

Discussion

Advances in technology have greatly reduced the incidence of the various complications of peritoneal dialysis. However, catheter migration and omental encapsulation continue to be of concern to nephrologists, as these two complications directly result in dysfunction of the peritoneal dialysis catheter and necessitate a second operation.

In this study, we found significant gender difference in the distance between the rectovesical pouch or rectouterinepouch and the pubic symphysis. The distance was greater in female patients, and therefore, a lower insertion site for the peritoneal dialysis catheter may be advisable in women to allow the catheter tip to reach the desired position. This

Table 3 Postoperative complications

Variable	Patient group		
	Traditional surgery group (A)	Modified surgery group (B)	*p* value
Patients (*n*)	157	189	NA
Migration [*n* (%)]	15 (9.6%)	1 (0.5%)	< 0.001
Omental encapsulation [*n* (%)]	12 (7.6%)	0 (0.0%)	< 0.001
Obstruction [*n* (%)]	5 (3.2%)	2 (1.1%)	0.252
Catheter manipulation reset	4 (2.5%)	1 (0.5%)	NA
Secondary surgery	23 (14.6%)	0 (0.0%)	< 0.001
Outer cuff extrusion [*n* (%)]	7 (4.5%)	8 (4.2%)	0.918
Hernia [*n* (%)]	3 (1.9%)	4 (2.1%)	1.000
Leakage [*n* (%)]	5 (3.2%)	4 (2.1%)	0.737
Inflow or outflow uncomfortable [*n* (%)]	7 (4.5%)	8 (4.2%)	0.918
Hemorrhage [*n* (%)]	12 (7.6%)	14 (7.4%)	0.934
Chylous ascites [*n* (%)]	1 (0.6%)	1 (0.5%)	1.000
Surgical wound infection [*n* (%)]	4 (2.5%)	5 (2.6%)	1.000

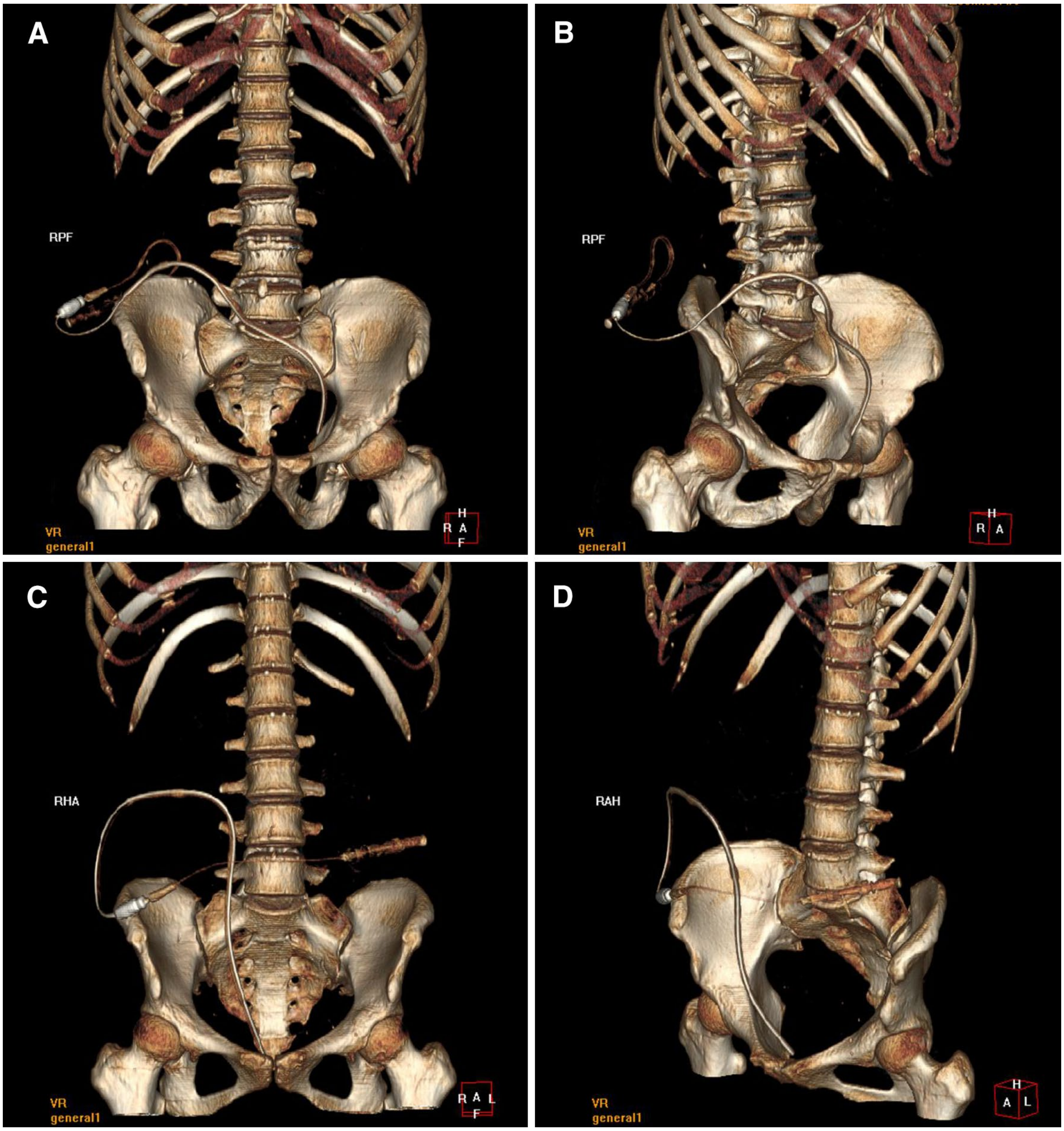

Fig. 3 Effect of modified surgery on location of peritoneal dialysis catheter. **a, b** Straight Tenckhoff catheter position and state after the traditional surgical procedure; **c, d** straight Tenckhoff catheter position and state after the modified surgical procedure

finding was confirmed on the median sagittal image of the abdomen.Since the distance from the inner cuff edge to the catheter tip was 15.0 cm, a 15 cm-long arc was drawn along the abdominal wall from the rectovesical pouch or rectouterine pouch to the desired insertion site on the anterior abdominal wall. Then, the distance from the pubic symphysis to the desired insertion site was measured. It is difficult to bend the catheter around the bladder or uterus (as shown in Fig. 2a, b) and into the rectal crypt because of the stiffness of the catheter. The surgeon can only place the catheter in the Douglas fossa. In our investigation, the distance from pubic symphysis to the ideal insertion site was about 9 cm for female patients and 11 cm for male patients (Table 2). The shorter distance in the former ensures that the tip of the catheter reaches the bottom of the Douglas pouch.

The straight Tenckhoff catheter inserted in the abdominal cavity by open surgery tends to move with peristaltic movements of the bowel and with changes in body position, and its free end is easily displaced. To prevent this, we embedded the inner cuff and part of the distal catheter in the rectus abdominis muscle. The catheter ran close along the flat posterior rectus sheath and pierced through the upper end of the incision in the anterior rectus sheath. Suturing of the anterior rectus sheath and fixing the catheter onto the peritoneum of the lateral abdominal wall caused a downward force to be exerted on the intra-abdominal segment of the catheter which, along with the force of gravity, tended to keep the catheter in position (Fig. 1). Because of the stiffness of the catheter, the springback is stronger when the unfixed intra-abdominal segment is shorter [4, 5]. Further, the fixation on the peritoneum keeps the catheter close to the parietal peritoneum. These measures help reduce the risk of catheter migration and the need for reoperation.

In recent years, much research has been done on methods to reduce the incidence of catheter migration and omental encapsulation. One approach is to implant the catheter at a lower site. The incidence of catheter migration after the traditional surgical procedure is 15.1%, whereas it is reported to be only 1.79% with the modified surgical procedure, in which the incision site is lower (7 cm above the pubic symphysis and 2–2.5 cm lateral to the midline) [6, 7]. However, a too low surgical incision might cause other problems [8]; first, low insertion of the catheter can lead todirect contact of the catheter tip with the floor of the pelvic cavity, with outflow of large volumes of peritoneal dialysis fluid from this area possibly causing the patient to experience pain or a persistent desire to defecate. Second, at the level of 4–5 cm below the umbilicus, the posterior abdominal oblique aponeurosis and the transversus tendon are directed all the way to the anterior rectus abdominis to be involved in sheath formation; this leads to absence of the rectus sheath posteriorly. Therefore, the peritoneum at this level is relatively weak, especially in female patients, and low catheter insertion could lead to peritoneal dialysis fluid leakage.

Kume et al. [9] attempted to prevent catheter migration and omental encapsulation by fixing the catheter to the retroperitoneal sheath with sutures 4 cm above the pubic symphysis and by removing all redundant omentum. They reported that while catheter migration occurred in eight patients (10.7%) who received traditional surgery, it did not occur at all in those who received the modified surgical approach with the additional suture fixation. The only issue was an increase in operation time. However, this method might increase the surgical steps and the risk of bleeding. The two-position fixation of the catheter will form a loop between the catheter and the abdominal wall. If a segment of intestine were to get trapped in this loop, intestinal obstruction could result. Further prospective studies are needed to assess the method.

Recently, some researchers have attempted laparoscopic peritoneal dialysis catheter insertion. Direct visualization of the omentum and the catheter position facilitates accurate insertion of the catheter into the Douglas fossa and permits removal of any extra omentum. The catheter can also be fixed by suture. The possibility of catheter migration and omental encapsulation can, therefore, be effectively reduced with this method. A meta-analysis of three randomized controlled trials and eight cohort studies showed that the laparoscopic catheter insertion technique had a lower rate of catheter migration than conventional surgery and alsoa higher 1-year catheter survival rate [10]. However, other studies have indicated that laparoscopic catheter placement is not superior to open surgery [11, 12]. Furthermore, laparoscopic catheter insertion requires general anesthesia, and so the benefits are balanced by the anesthesia-related risks and higher cost. Although general anesthesia is routinely used for this operation in developed countries, this is not the practice in developing countries. One disadvantage with the laparascopic method is that the nephrologist cannot perform the operation independently, but will require the assistance of a surgeon [13]. In developing countries, there are many areas where laparoscopic equipment and qualified staff are not available. In addition, the cost of the laparoscopic catheter insertion procedure is 3–4 times higher than that of traditional surgery [14]. However, laparoscopic catheter placement has obvious advantages in patients who have had prior abdominal surgery.

The percutaneous technique, using a guide wire and peel-away sheath, is another procedure that could be performed under local anesthesia. Percutaneous placement is simple and can save operating time and therefore is well suited for weak and high-risk patients who cannot tolerate general anesthesia or open surgery. As the method involves “blind” placement of the catheter, there is associated risk of abdominal viscera puncture and serious bleeding. In addition,the reported catheter dysfunction rate varies between 3.98% and 19.8% [15–18].

In addition to different operative techniques, nephrologists have also used different kinds of catheters, including the straight Tenckhoff catheter, swan neck catheter, and coiled-tip catheter, in the attempt to decrease catheter-related complications. One study reported no difference in complication rates and catheter survival between the straight Tenckhoff catheter and the swan neck catheter [19]; however, the straight Tenckhoff catheter has shown significantly better survival than the coiled-tip catheter [20, 21]. The self-locating catheter has also been applied. This catheter is similar to a Tenckhoffcatheter but includes a small tungsten cylinder at the distal end which, through the effect of gravity, directs the tip to the rectovesical space and helps prevent dislocation. Studies have shown that the self-locating catheter can bring down the dislocation rate to 1.0% [22–24]. However, this is at the cost of other problems. Moreiras’s group reported severe pelvic pain in 4.2% of their patients and breaks in the catheter in 7.1% patients [25]. In another study, Minguela et al. reported that 3.8% of self-locating catheters had to be removed because of exit-site infection [26]. It is possible that some of these problems were the result of manufacturing defects in the early catheters or faulty implantation techniques.

To conclude, this study shows that the modified peritoneal dialysis catheter insertion technique can reduce the incidence of catheter migration and omental encapsulation and improve the technical survival rate of the catheter. The modified implantation technique is relatively simple, safe, and inexpensive, and should be recommended for use in most patients with end-stage renal disease in developing countries.

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Compliance with ethical standards

Disclosure The authors have nothing to disclose.

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