International Urology and Nephrology (2019) 51:1053–1058
https://doi.org/10.1007/s11255-019-02164-8

NEPHROLOGY - ORIGINAL PAPER

Peritoneal dialysis catheter insertion using a very-low-site approach: a 5-year experience

Li-Feng Gong[1] · Jing-Kui Lu[1] · Wei-Gang Tang[1] · Wei Xu[1] · Ming Xu[1] · Gui-Xiang Ma[1]

Received: 6 March 2019 / Accepted: 30 April 2019 / Published online: 14 May 2019

Abstract

Purpose Peritoneal dialysis (PD) catheter tip migration accounts for the majority of cases of PD catheter malfunction. In this case series, we described our experiences of using a modified PD catheter implantation approach through a site that is lower than the site that is conventionally used, to reduce catheter malfunction.

Methods We retrospectively identified 76 patients who received PD catheter implantation at the Affiliated Wujin Hospital of Jiangsu University, among whom 39 received the traditional approach of low-site insertion and 37 received a modified approach of very-low-site insertion. All participants were followed up for at least 2 years after PD catheter implantation, and the development of catheter dysfunction or death during this period was monitored.

Results We found that the survival rate of the initially inserted catheter was 75.68% among the very-low-site group. This survival rate was significantly better than that observed among the low-site group (48.72%; $p=0.029$). Kaplan–Meier curves of the initial catheter survival also showed that the catheter survival was significantly higher in the patients in the very-low-site group than those in the low-site group (log rank $p=0.012$). Complications, such as catheter tip migration, were not observed in the very-low-site group, while tip migration occurred in 15.38% of the patients in the low-site group (very-low-site group vs low-site group: $p=0.039$).

Conclusions A safe and simple PD catheter implantation can be performed either through the low-site approach or the very-low-site approach.

Keywords Peritoneal dialysis · Peritoneal dialysis catheter · Catheter dysfunction

Introduction

Peritoneal dialysis (PD) is one of the renal replacement therapy (RRT) options for patients with end-stage renal disease (ESRD). PD is well known as a home-based treatment with economical advantages over other RRT options. Thus, the 'PD first' policy is increasingly upheld in many countries [1, 2]. To establish and maintain a safe and patent PD catheter is a prerequisite for the successful implementation of PD. Complications, including PD catheter tip migration and obstruction, remain important concerns regarding this technique [3].

Recently, much progress has been made in the refinement of the surgical techniques related to PD catheter implantation [4–6]. Findings from the majority of studies concur that laparoscopic PD catheter implantation can significantly lower the risk of catheter tip migration and obstruction [6, 7]. However, in developing countries like China, widespread use of laparoscopic PD catheter implantation can be difficult, due to the high cost and the requirement for adequate technique training. Consequently, local nephrologists have developed a specific technique of PD catheter implantation through a low-site approach that is suitable for the Chinese population [8].

Based on our experiences, we found that, although this low-site approach could reduce the incidence of catheter tip migration and obstruction, the incidence of these complications was still higher than those associated with laparoscopic PD catheter implantation. The advantage of a laparoscopic approach may lie in the fact that the peritoneal implantation site in the laparoscopic approach is lower than that used in

✉ Li-Feng Gong
nephrology@163.com

[1] Department of Nephrology, Affiliated Wujin Hospital of Jiangsu University, No. 85 Gehu East Road, Wujin District, Changzhou 213002, Jiangsu, China

the low-site approach. Inspired by this rationale, we started to explore how low the peritoneal insertion site could be during PD catheter implantation. After a series of attempts using different insertion routes, we learned that a distance of 4 cm above the pubic symphysis appeared to be the lowest possible peritoneal insertion site using the traditional surgical procedures. This approach was termed the very-low-site PD catheter implantation technique. This study aimed to describe our experience investigating the efficacy and complications of the traditional low-site and our novel very-low-site approach of PD catheter implantation. We hypothesized that the very-low-site approach was superior to the low-site approach in reducing the complications that are related to catheter implantation.

Methods

Patient enrollment

This was a retrospective analysis. Seventy-six consecutive ESRD patients who received PD catheter implantation in the Affiliated Wujin Hospital of Jiangsu University between August 2011 and December 2016 were enrolled.

Among these patients, 39 received the traditional low-site PD catheter implantation between August 2011 and June 2015 and 37 received the new very-low-site implantation between June 2015 and December 2016. In the low-site group, the peritoneal implantation site was 7 cm above the pubic symphysis and 2 cm to the left of the linea alba. In the very-low-site group, the peritoneal implantation site was 4 cm above the pubic symphysis and 3 cm to the left of the linea alba.

PD catheter implantation procedures

All of the PD catheter implantation surgeries were performed by the corresponding author, while patients were under spinal anesthesia, using an open surgery with straight Tenckhoff catheters.

Before each operation, urethral catheterization was used to empty the patients' bladder. Upon incising the peritoneum, the distance between the site of peritoneal entry and the rectovesical pouch (Douglas pouch) was measured using oval forceps. The PD catheters were adjusted to fit this distance through removal of excess. After catheter insertion, the site of peritoneum incision was closed with a purse-string suture just below the inner cuff, followed by an infusion of 2 L of 1.5% glucose dialysate through the PD catheter to check for leakage. Intermittent PD was initiated immediately after catheter implantation using 1–2 L of 1.5% glucose dialysate, depending on patient's tolerance.

There were major differences in the site of the skin incisions between the two groups. In the low-site group, skin incisions of approximately 3–4 cm length were longitudinally made 7 cm above the pubic symphysis and 2 cm to the left of the linea alba as the center. Subcutaneous tunnels of PD catheter were curved and exited to the right of the linea alba (Fig. 1a). In the very-low-site group, skin incisions of ~ 3–4 cm length were longitudinally made 4 cm above the pubic symphysis and 3 cm to the left of the linea alba as the center. In this group, subcutaneous tunnels of PD catheter were also curved and exited to the right of the linea alba (Fig. 1b).

PD training before and after catheter implantation

All of the patients were trained by the same nursing team at our department, with training programs that were initiated before implantation. The program included simulation of the PD operation preoperatively, preparation of usage and environment, wound care, diet, bathing, and daily life education, and management during the emergent situations. Each patient performed PD under the guidance of nurses, usually 5–7 days after implantation. Patients were only able to be discharged from the hospital after passing an examination for PD techniques. After discharge, all patients received continuous ambulatory PD (CAPD).

Data collection

Through the electronic medical record system, we collected inpatient and emergency medical records, laboratory and equipment examinations, and image data. Each patient was followed up for at least 2 years after catheter implantation, and we monitored whether the patients developed catheter dysfunction or died during the follow-up period.

We defined catheter dysfunction as persistent failure to perfuse or to drain effluent within 30 min. We also defined catheter tip migration as the malposition of the tip out of the true pelvis on a plain abdominal radiograph.

Statistical analysis

We analyzed data using SPSS19.0. Metrological data were described by mean ± standard deviation, and a *t* test was used to compare between groups. A Chi-square test was used to compare categorical data between groups. PD catheter survival was described and analyzed by the Kaplan–Meier method. A value of $p < 0.05$ was deemed to be statistically different.

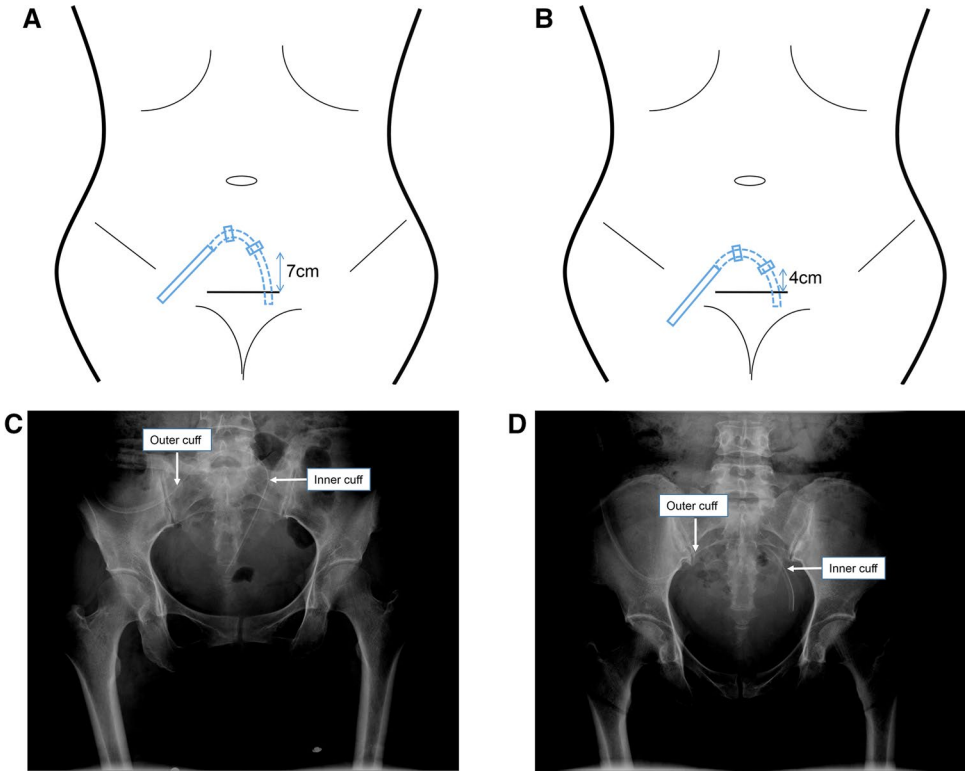

Fig. 1 Comparison of the low-site approach and the very-low-site approach. **a** A diagrammatic sketch of low-site implantation. **b** A diagrammatic sketch of very-low-site implantation. **c** A radiograph of a straight Tenckhoff catheter by low-site implantation. **d** A radiograph of a straight Tenckhoff catheter inserted by very-low-site implantation

Table 1 Demographic data and clinical outcomes

Variables	Low-site	Very-low-site	*p*
Patients	39	37	
Sex (number of men:women)	20:19	22:15	0.627
Age (years)	56.52 ± 12.93	59.86 ± 13.68	0.372
BMI (kg/m^2)	23.36 ± 3.73	24.51 ± 3.23	0.396
Origin of ESRD [*n* (%)]			0.451
Glomerulonephritis	23 (58.97)	22 (59.46)	
Diabetic nephropathy	10 (25.64)	6 (16.22)	
Hypertension	4 (10.26)	8 (21.62)	
Other causes	2 (5.13)	1 (2.70)	
Death [*n* (%)]	6 (15.38)	4 (10.81)	0.802
Initial catheter survival [*n* (%)]	19 (48.72)	28 (75.68)	0.029

Results

We retrospectively analyzed 76 patients, among whom 39 belonged to the low-site group and 37 belonged to the very-low-site group. There was no statistical difference in the patient numbers, sex, age, body mass index (BMI), the origin of ESRD, or mortality rate between the two groups (Table 1).

The PD catheter survival rate of the first catheter was 75.68% in the very-low-site group, which was significantly higher than that observed in the low-site group ($p = 0.029$). Kaplan–Meier curves of the PD catheter survival also showed the same findings (log rank $p = 0.012$; Fig. 2). There was a significant difference in the complications

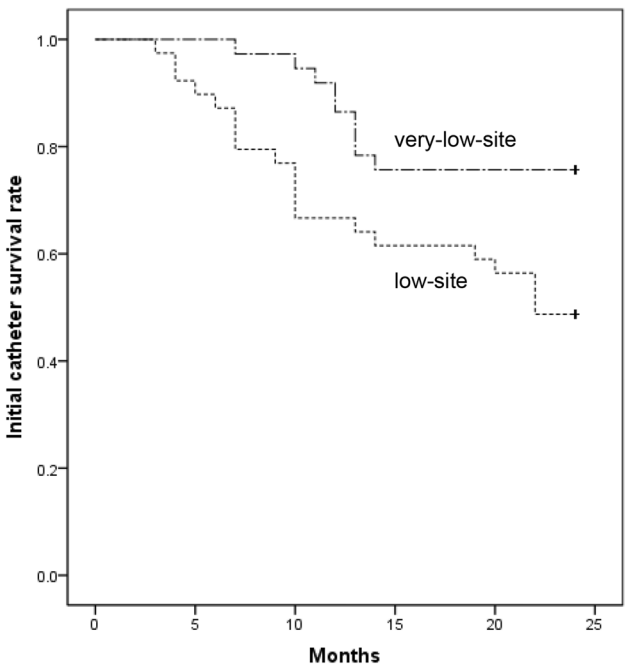

Fig. 2 Initial catheter survival rate in the two groups (log rank $p = 0.012$)

of catheter tip migration within 2 years between the two groups ($p = 0.039$; Table 2); catheter tip migration did not occur in any of the very-low-site group patients, while 15.38% of the patients in the low-site group developed this complication.

There was no significant difference in the rate of complications, such as peritonitis, tunnel infection, wound bleeding, dialysate leakage, and abdominal hernia, between the two groups (Table 2). In the low-site group, six patients subsequently switched to hemodialysis due to peritonitis, while only four patients switched to hemodialysis in the very-low-site group. In addition, none of these patients sustained intraoperative bladder injury. We observed that the time of effluent drainage among all patients was less than 30 min after catheter implantation, without any episodes of inflow or outflow pain. None of these patients experienced constipation or other gastrointestinal problems.

Discussion

Through a retrospective analysis of 76 patients, we found that PD catheter implantation through the traditional low-site and novel very-low-site approach were both safe, simple, and facilitated permanent PD catheter implantation. The initial PD catheter survival rate and the incidence of complications, including catheter tip migration, were better in the very-low-site group than in the low-site group. Although the initial catheter survival rates in both of the groups in this study were lower than those reported by other studies with excellent outcomes [2, 9], our findings were similar to the results from local practices in general [8, 10]. We suspect that the discrepancy between our results and those of other studies may be due to the fact that the dialysates that are used in our patients are glucose-containing formulae.

Table 2 Complications between the two groups

Variable	Low-site [*n* (%)]	Very-low-site [*n* (%)]	*p*
Patient (*n*)	39	37	
Peritonitis			
Episodes	21 (53.85)	19 (51.35)	0.828
Episodes/patient–month	0.039	0.034	
Tunnel infection	5 (12.82)	3 (8.11)	0.768
Catheter tip migration	6 (15.38)	0	0.039
Hernia	3 (7.69)	1 (2.70)	0.646
Bleeding	0	0	–
Leakage	0	0	–
Inflow or outflow pain	0	0	–

The straight Tenckhoff catheter was originally designed for PD catheter implantation through a higher site. The catheter has been found to be too long for application in catheter implantation through a lower site. According to prior experiences from the other groups [8], we removed the excess parts of the PD catheters during the operation. We found no adverse effects of catheter trimming with regard to drainage time, the incidence of inflow or outflow pain, and the risk of injury to abdominal viscera introduced by the trimmed catheter. These results are consistent with other reports [8].

Despite the costs of the operation and the requirement for an adequate technique, it is believed that laparoscopic PD catheter implantation is the first choice if we wish to reduce the complication rate of catheter tip migration and obstruction [9, 11–15]. During the laparoscopic procedure, the catheter tip is slipped into the sheath of the rectus abdominis until it approaches the upper edge of the pubic symphysis and penetrates the peritoneal cavity. Several researchers believe that this method can lead to a reduction in the frequency of catheter tip migration [12–15]. In our very-low-site approach, the site through which the catheter entered the peritoneal cavity was close to the upper border of the pubic symphysis. A literature review showed that the lowest catheter implantation site reported by others was 5 cm above the upper border of the pubic symphysis [16]. However, after a series of explorations, we discovered that a site 4 cm above the pubic symphysis might be the lowest possible site of peritoneal entry that is feasible using the traditional open surgical procedures. Another technique for preventing catheter tip migration is catheter fixation, which is usually conducted by a laparoscopy. However, catheter fixation can cause unbearable pain during the catheter maneuver in some patients. In 2014, researchers from China introduced an open surgery technique of PD catheter insertion with catheter fixation onto the lower abdomen wall, using an instrument called the 'catheter fixation kit' [17], without the observance of catheter tip migration or traction pain. In their experience, the fixation site of the PD catheter was also close to the upper border of the pubic symphysis. In our experience, the very-low-site approach exhibited a similar efficacy without the requirement of a complex operation.

Compared with the results observed in the low-site group, the intra-abdominal PD catheter position in the very-low-site group was lower and less likely to be disturbed by the greater omentum and intestinal peristalsis. Encapsulation by and traction from the greater omentum are important factors in the precipitation of catheter tip migration and obstruction. However, the greater omentum would not be detectable at 4 cm above the upper border of the pubic symphysis. In addition, when subcutaneous tunneling was performed, the exit site of the tunnel and the entry site into the peritoneum were placed on different sides of the linea alba. Using this arrangement, the left side of the intra-abdominal catheter

was immobilized by the pelvic wall, while the right side was partially immobilized, rendering difficulty in catheter bending and migration, due to the compliance of the catheter (Fig. 1d). Therefore, our approach of very-low-site catheter implantation appears to be more advantageous for reducing the complications of catheter tip migration. Because the catheter entry site is at a lower position, the catheter inserted in the very-low-site group was less disturbed not only by the greater omentum and intestinal peristalsis, but also by extracorporeal factors, such as belts, that potentially improve the long-term survival, as observed in this study.

Anatomically, the lower the anterior abdominal wall, the thicker the peritoneum is. This feature can be beneficial in the creation of the purse suture around the peritoneal incision site. A thicker peritoneum is difficult for surgeons to pull apart during suture, resulting in a lower incidence of complications, such as dialysate leakage, after operation. We routinely infused 2 L of dialysate during catheterization to check for leakage, and intermittent PD was performed immediately after the operation, without the observance of any leakage. Although current guidelines recommend that PD be started 2 weeks after PD catheter implantation [18], we found that intermittent PD can be performed immediately after the operation, as long as the peritoneal incision site was sutured firmly and 2 L dialysate was infused intraoperatively to confirm the absence of leakage. This practice can avoid temporary hemodialysis catheter placement for emergent RRT.

In summary, the very-low-site PD catheter implantation approach has several advantages, including a lower rate of catheter tip migration, longer initial catheter survival, earlier PD initiation, and simpler surgical procedures. Consequently, we believe that the approach of very-low-site PD catheter implantation may be worth promoting. However, there are still shortcomings in this study. First, the number of patients included is relatively low, and further randomized, double blind, and large-scale studies are needed to confirm the current results. Second, the retrospective nature of this study also limits its applicability.

Conclusions

Safe and simple PD catheter implantation can be achieved through both the low-site approach and the very-low-site approach. Our results suggest that the very-low-site implantation approach might be superior to the low-site approach, regarding the reduced rate of catheter tip migration.

Acknowledgements This study was supported by Jiangsu University Medical Clinical Science and Technology Development Fund of China (JLY20160035) and Changzhou Wujin Science and Technology Bureau Fund of China (WS201610).

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This study was approved by the ethics committee of the Affiliated Wujin Hospital of Jiangsu University. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent Written informed consent was obtained from all individual participants included in the study.

References

1. Liu FX, Gao X, Inglese G, Chuengsaman P, Pecoits-Filho R, Yu A (2015) A global overview of the impact of peritoneal dialysis first or favored policies: an opinion. Perit Dial Int 35:406–420
2. Choy AS, Li PK (2015) Sustainability of the peritoneal dialysis-first policy in Hong Kong. Blood Purif 40:320–325
3. Ma TK, Chow KM, Kwan BC, Ng JK, Choy AS, Kwong VW, Pang WF, Leung CB, Li PK, Szeto CC (2018) Peritoneal dialysis catheter revision and replacement by nephrologist for peritoneal dialysis catheter malfunction. Nephron 138:214–219
4. Asif A (2005) Peritoneal dialysis catheter insertion. Minerva Chir 60:417
5. Lan L, Jiang J, Wang P, Ren W, Hu Z (2015) Peritoneal dialysis catheter placement in the right lower quadrant is associated with a lower risk of catheter tip migration: a retrospective single-center study. Int Urol Nephrol 47:557–562
6. Shrestha BM, Shrestha D, Kumar A, Shrestha A, Boyes SA, Wilkie ME (2018) Advanced laparoscopic peritoneal dialysis catheter insertion: systematic review and meta-analysis. Perit Dial Int 38:163–171
7. Mo M, Ju Y, Hu H, Zhang W, Pan J, Zheng Q, Chen J, Su L, Dou X (2017) Peritoneal dialysis catheter emplacement by advanced laparoscopy: 8-year experience from a medical center of China. Sci Rep 7:9097
8. Zhang L, Liu J, Shu J, Hu J, Yu X, Mao H, Ren H, Hong H, Xing C (2011) Low-site peritoneal catheter implantation decreases tip migration and omental wrapping. Perit Dial Int 31:202–204
9. Pan A, Poi MJ, Matos J, Jiang JS, Kfoury E, Echeverria A, Bechara CF, Lin PH (2016) Long-term outcomes of single-port laparoscopic placement of peritoneal dialysis catheter. Vasc Endovasc Surg 50:343–348
10. Jiang C, Xu L, Chen Y, Yan X, Sun C, Zhang M (2014) A modified open surgery technique for peritoneal dialysis catheter placement decreases catheter malfunction. Perit Dial Int 34:358–367
11. Shen Q, Jiang X, Shen X, Yu F, Tu Q, Chen W, Ye Q, Behera TR, He Q (2017) Modified laparoscopic placement of peritoneal dialysis catheter with intra-abdominal fixation. Int Urol Nephrol 49:1481–1488
12. Keramati MR, Abbaszadeh-Kasbi A, Keshvari A (2018) Laparoscopic omentopexy, rectus sheath tunneling and implantation of the peritoneal dialysis catheter using a peritoneal dialysis port. Perit Dial Int 38:187–191
13. Krezalek MA, Bonamici N, Lapin B, Carbray J, Velasco J, Denham W, Linn J, Ujiki M, Haggerty SP (2016) Laparoscopic peritoneal dialysis catheter insertion using rectus sheath tunnel and selective omentopexy significantly reduces catheter dysfunction and increases peritoneal dialysis longevity. Surgery 160:924–935

14. Tu QD, He Q, Shen XG, Jiang XX, Liu YM, Shen QQ, Zhang HJ, Chen WF, Yao LX (2016) Clinical comparison of modified laparoscopic and conventional placement of peritoneal dialysis catheters. Zhonghua Yi Xue Za Zhi 96:3586–3589
15. Keshvari A, Keramati MR, Nassajian MR, Mohsenipour M, Nouritaromlou MK (2016) Introduction of a new laparoscopic trocar for insertion of peritoneal dialysis catheters and making a proper rectus sheath tunneling. Surg Endosc 30:5325–5329
16. Dell'aquila R, Chiaramonte S, Rodighiero MP, Di Loreto P, Spano E, Nalesso F, Cruz D, Kuang D, Ronco C (2006) The Vicenza "Short" peritoneal catheter: a twenty year experience. Int J Artif Organs 29:123–127
17. Wang H, Jia H, Lv X, Ding G (2014) Peritoneal catheter fixation to the abdominal wall in surgical catheter implantation to prevent malfunction. Blood Purif 38:109–114
18. Figueiredo A, Goh BL, Jenkins S, Johnson DW, Mactier R, Ramalakshmi S, Shrestha B, Struijk D, Wilkie M (2010) Clinical practice guidelines for peritoneal access. Perit Dial Int 30:424–429