Original Article

A Simplified Technique of Rectus Sheath Tunneling in Open Peritoneal Dialysis Catheter Insertion

Prinya Akranurakkul, MD[1], Dolrudee Songtish, MD[1], Jirayut Janma, MD[2], Siribha Changsirikulchai, MD[2]

[1] Department of Surgery, Faculty of Medicine, Srinakharinwirot University, Nakhon Nayok, Thailand
[2] Department of Internal Medicine, Faculty of Medicine, Srinakharinwirot University, Nakhon Nayok, Thailand

Background: Peritoneal dialysis (PD) is the preferred treatment for patients with chronic kidney disease (CKD), however, complications associated with PD catheter placement often result in a patient transferring to hemodialysis (HD). Rectus sheath tunneling is a relatively new technique for laparoscopic PD catheter insertion, aimed at reducing these complications. We examined the outcomes of open PD catheter insertion with rectus sheath tunneling (R-PD) to assess whether the technique decreases these kinds of complications and improves the quality of treatment for CKD patients.

Materials and Methods: A retrospective review was undertaken of 40 CKD patients who had undergone R-PD catheter insertion. The details of R-PD catheter insertion technique, along with a summary of the outcomes, including catheter-related complications and survival time, were reported.

Results: Forty CKD patients were 19 women and 21 men, ranging from ages 24 to 88. Mean operative time for R-PD insertion was 28 minutes (SD, 11.9). Three patients experienced minor abdominal wall bleeding and no patients had iatrogenic visceral organ injury. Catheter dysfunction was found in 3 patients (7.5%). Median catheter survival time was 23 months. Number of functioning catheters at 12 and 24 months were 16 and 14. Cumulative catheter survival rate at 12 and 24 months were 50% and 44%, respectively.

Conclusion: Comparable outcomes were found between R-PD insertion technique and others. Although further research is necessary to ensure that these findings apply over a large group of patients, our results suggest that R-PD insertion is as straightforward, effective, and reproducible as other techniques while offering lower rates of catheter-related complications.

Keywords: Peritoneal dialysis; Open catheterization; Rectus sheath tunneling; Retrospective studies; End stage renal disease

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Renal replacement therapy (RRT) is the main treatment for stage 5 chronic kidney disease (CKD). The treatment is comprised of a number of techniques, usually including some kind of dialysis. Dialysis can be administered either through the peritoneum of the patient (peritoneal dialysis), or via intravenous, arteriovenous, or synthetic graft mechanisms (hemodialysis). Generally, peritoneal dialysis (PD) is preferred over hemodialysis (HD), as it allows for greater patient autonomy[(1)] and is associated with superior renal function preservation[(2)]. Moreover, PD is more cost effective than HD. These advantages have led to many countries adopting a "PD first" policy, including Hong Kong, many Scandinavian countries, and the United Kingdom[(3)].

In Thailand, the National Health Security Office (NHSO) adopted a "PD-first" policy in 2008. Since then, the country has also witnessed a rise in the number of patients requiring RRT, most of whom are primarily treated with PD (where there is no contraindication)[(4)]. Although many new methods of PD catheter insertion have been developed since Tenckhoff pioneered his innovative approach in 1970[(5)], most CKD patients in Thailand are still treated with the open PD catheter placement technique using minilaparotomy, which is preferred for its convenience and the fact that it can be undertaken under local anesthesia. For more complicated cases, such as those where there is a failed opened technique, laparoscopic PD catheter placement is used.

However, complications after catheter placement are still relatively high (27.6 to 30.3%), largely as a result of outflow obstructions such as omental wrapping and tip migration (10 to 13%)[(6,7)]. Moreover, PD catheter insertion by minilaparotomy, which is the current preferred method in Thailand, is a blind technique, which occasionally results in catheter malposition. Given that the success of peritoneal dialysis achievement is dependent on the survival of the PD catheter, these rates of complications are far from optimal.

Rectus sheath tunneling was introduced by Comert et al in 2005 as a new technique for laparoscopic PD catheter insertion[(8)]. Rectus sheath tunneling inserts the PD catheter via a tangential passage through a transmural segment of the abdominal wall. By inserting the catheter via the musculofascial tunnel, the technique is aimed at stabilizing

Correspondence to:

Akranurakkul P.

Department of Surgery, Faculty of Medicine, Srinakharinwirot University, 62 Moo 7 Ongkharak, Nakhon Nayok 26120, Thailand.

Phone: +66-37-395085 ext. 11201, **Fax:** +66-37-395271

Email: prinyaak@g.swu.ac.th

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the orientation of the PD catheter and preventing tip migration. Most studies report impressive results from laparoscopic PD insertion with rectus sheath tunneling(9-12). However, no research has thus far been conducted on its efficacy in procedures using the minilaparotomy technique. To address this gap, we examined the outcomes of open PD catheter insertion using the minilaparotomy technique with rectus sheath tunneling to assess whether the technique increases the PD catheter survival rate and improves the quality of treatment for CKD patients.

Materials and Methods

After obtaining ethical approval from the Institutional Review Board of the Faculty of Medicine of Srinakharinwirot University, a cross-sectional retrospective review was undertaken of 40 adult CKD patients (19 women and 21 men) who had undergone PD catheter insertion between December 2016 and June 2017 at HRH Princess Maha Chakri Sirindhorn Medical Center (MSMC) in Nakhon Nayok, Thailand. Open PD catheter insertion with rectus sheath tunneling (R-PD insertion) was performed in 40 patients. Data from patients who had undergone simultaneous catheter replacement or laparoscopic PD catheter insertion were omitted. Demographic data, clinical outcomes, and associated complications for the patients were collected from their medical records. Data were analyzed using the statistical software SPSS v.23. For all continuous data, the mean was calculated, and for all categorical data, the count and percent were obtained. The outcomes of R-PD insertion and PD catheter survival time were calculated using a Kaplan-Meier curve.

Rectus sheath tunneling catheter insertion techniques

All procedures were performed in the operating room, and prophylactic antibiotics were administrated 30 minutes before the operation. Patients fasted for six hours before the operation and underwent enemas the night before. They were also encouraged to empty their bladders immediately prior to the operation. Patients were placed in the supine position on the operating table, after which routine field sterility procedures were performed. All procedures were done under local anesthesia. All PD catheters had a coiled tip and were double-cuffed.

The first incision to enter the abdominal cavity was made at the suprapubic region, 2-3 fingerbreadths (FB) above the pubic symphysis (Figure 1A). A 3 to 4 cm midline incision was performed following adequate anesthesia injection. We usually injected 10 mL of 1% lidocaine with adrenaline at the skin and subcutaneous layer, 10 mL at the rectus muscle, sheath and peritoneum layer, and 5 to 10 mL at the subcutaneous tunnel and exit site. The incision was deepened through the linea alba and rectus muscle. The muscles were then gently separated from each other. Following the peritoneum incision, the tip of PD catheter was gradually inserted into the pelvic cavity in the caudal direction, via the use of a guide wire (Figure 1B). Once the catheter tip had

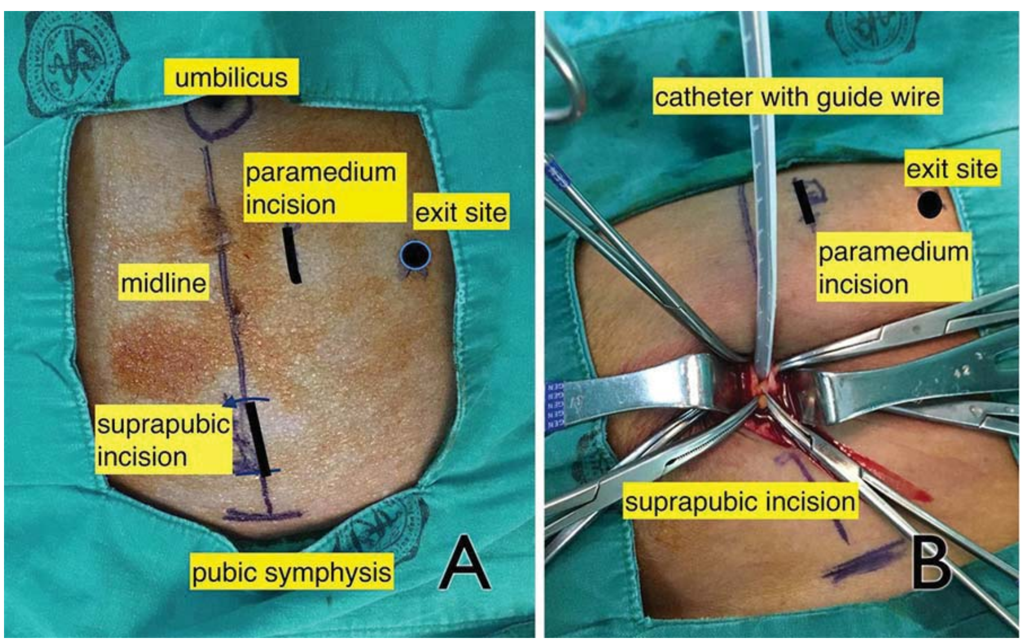

Figure 1. A) Pre marking incision for R-PD catheter insertion, B) PD catheter insertion at supra-pubic incision using guide wire.

been placed into the cul de sac, the guide wire was completely withdrawn. The second paramedian incision was 1 to 2 cm long and positioned 3 to 4 cm inferiolateral to the umbilicus. This incision was located at the location of the deep cuff of the PD catheter and intended to cut superficially through the skin and subcutaneous layers. The rectus sheath tunnel extended 4 to 5 cm between the suprapubic incision and the paramedian incision. The tunnel was initiated manually by index finger guide, followed by use of a tunneler (Faller stylet), which was attached to the PD catheter via the preperitoneal layer (Figure 2A). The tip of the tunneler was advanced in a cephalic and lateral direction, passed though rectus muscle and sheath, and followed a curved trajectory toward the paramedian incision (Figure 2 B and C).

Because tunnel creation can result in injury to inferior epigastric vessel, care was taken to place the tunnel near the midline and laid medial to the vessel. The extraperitoneal part of the PD catheter and the cuff were pulled out along the same route as the tunneler, using gentle traction until the deep cuff was beneath the anterior rectus sheath and the proximal cuff was set into the subcutaneous layer. After the deep cuff was adjusted and positioned beneath the anterior rectus sheath, the PD catheter with tunneler was advanced though the subcutaneous layer and exited at the pre-marked exit site (Figure 3). The exit site positioned caudally and laterally to the deep cuff. The superficial cuff was in the subcutaneous layer without kinking and was located 1 to 2 cm away from the exit site. A flow test was checked during the intraoperative time by irrigating 60 mL of normal saline and confirming that at least 30 to 40 mL is

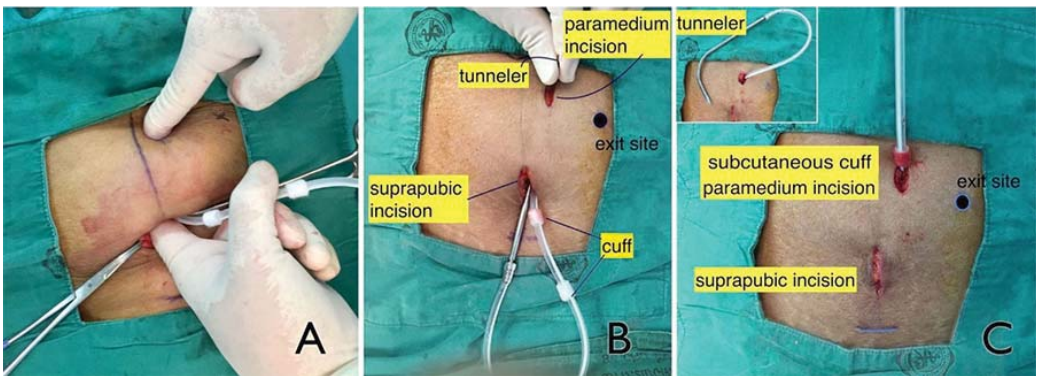

Figure 2. A) Manual creation of rectus sheath tunnel with index finger, B and C) Tunneler passing through rectus sheath tunnel and exiting at paramedian incision.

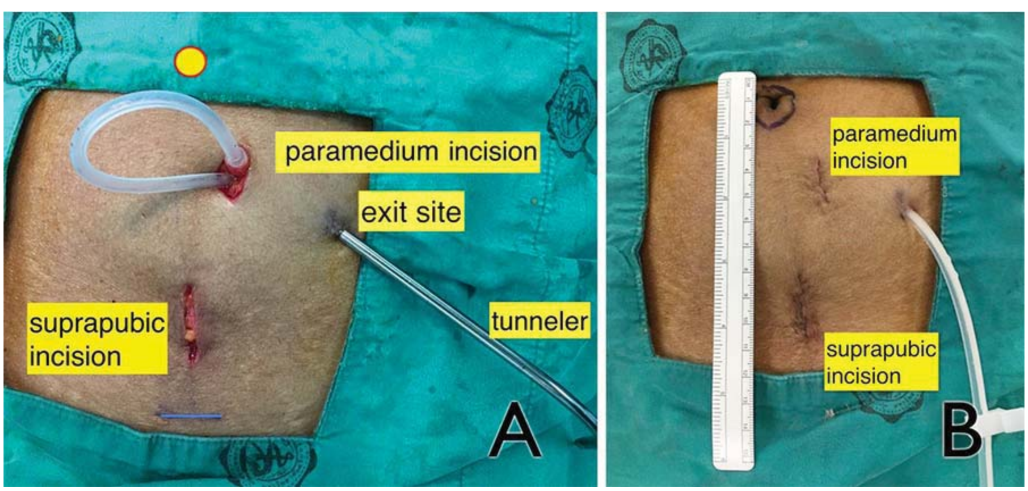

Figure 3. PD catheter with tunneler passing through subcutaneous tunnel and exiting at exit site.

easily aspirated. Post-operative imaging assessed the location of the catheter. In patients whose PD catheter was located outside the pelvic cavity with outflow obstruction, revision was recommended. All surgical wounds were checked and closed layer by layer. PD catheter function and any immediate complications were routinely evaluated at our PD clinic. All patients stayed overnight after PD insertion and a break-in time of 14 days was allocated.

Results

Of the 40 adult CKD patients (19 women and 21 men, aged between 24 and 88, with a mean age of 60) underwent R-PD insertion. Mean BMI was 22.83 kg/m^2. The mean operative time for those in the R-PD insertion group was 28.0 minutes. Three patients had abdominal wall bleeding which was stopped using manual compression; no other intervention was needed. No patient in R-PD insertion suffered from an iatrogenic bowel or bladder injury. Post-operative imaging, which was performed after the R-PD insertion, confirmed that the catheter tip was still optimally located in the pelvic cavity in 36 cases. In four cases, the tip had migrated to the right iliac fossa, which was deemed acceptable as the catheter continued to function normally. Two patients required revision 8 and 6 weeks after first insertion. Outflow obstruction was revised successfully using the technique previously described by Songtish et al[13]. Two patients had peritonitis which one had improved by medication while the other changed to hemodialysis and had his catheter removed. No late complications such as leakage, hernia, and tunnel or exit site infection were observed (Table 1).

The follow-up period ranged from 45 to 50 months, and the mean was 47.63 months (SD=1.61). Of 40 patients, 21 patients died from non-catheter related causes, 8 patients lost to follow-up and 11 patients were still alive. All passed-away patients still had functioning PD catheters. Catheter median survival time was found to be 23.0 months (Figure 4). Number of functioning catheters were 16 and 14 at 12 and 24 months. Cumulative catheter survival rates at 12, 24, 36 and 48 months were 50%, 44%, 17% and 17%, consecutively.

Table 1. Demographic data and outcomes in rectus sheath tunneling peritoneal dialysis catheter insertion

Variable	Rectus sheath tunneling peritoneal dialysis catheter insertion (n=40)
Age in years (mean (SD))	60.18 (15.29)
Male	21 (52.5%)
Operative time in minute (mean, SD)	28.0 (11.9)
Previous operation	12 (30%)
Post-operative complication	
Minor bleeding	3 (7.5%)
Catheter flow obstruction	2 (5%)
Peritonitis	2 (5%)
Revision	2 (5%)
Catheter dysfunction	3 (7.5%)

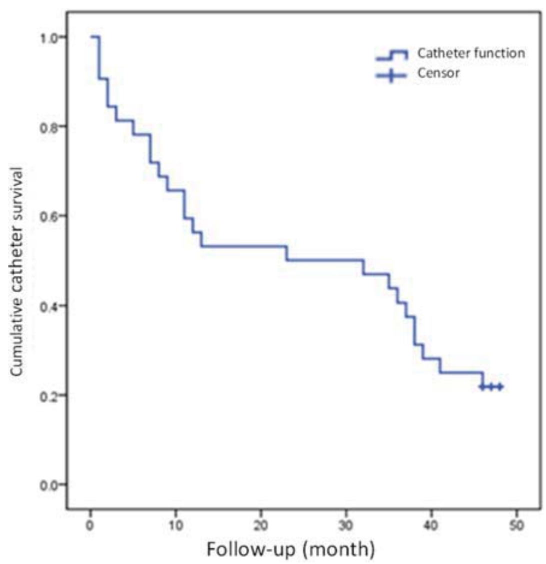

Figure 4. Kaplan-Meier catheter cumulative survival R-PD catheter insertion.

Discussion

Peritoneal dialysis is a globally accepted modality of treatment for CKD patients. Following the innovative PD placement techniques pioneered by Tenckhoff[5], there has been a marked rise in the number of new PD placement techniques that have been made available, all of which offer comparable outcomes for non-complex patients[14]. However, despite these developments, many CKD patients still shift from PD to HD due to catheter-related complications in the first year[15]. As such, a reduction in the rate of PD catheter-related complications is essential if patients are to remain on the optimal form of dialysis.

Several surgical techniques have been developed to reduce the rates of catheter-related complications, including those aimed at reducing outflow obstruction, infection, and leakage. For instance, although minilaparotomy has been the standard technique for many years, recent evidence that laparoscopic insertion may be associated with lower rates of catheter-related complications, has led some countries to favor this technique[9,16]. Laparoscopic PD catheter placement was first established by Amerling et al in 1993[10] and since then has undergone significant development and become widely acceptable[11]. Advanced laparoscopic surgery techniques, such as omentoplexy and the fixation of the catheter tip to either the abdominal wall or an adjacent organ have been reported, however catheter dysfunction and migration were still found in 5 to 8% of cases[12,17]. Moreover, the fixation point used in these techniques has also been associated with internal hernias and difficult catheter removal.

The rectus sheath tunneling technique was developed to reduce these kinds of complications. It aims to maintain catheter orientation, prevent tip migration, and reduce leakage. Comert et al were the first to report the potential benefits of laparoscopic PD insertion with rectus sheath tunneling[8]. In their 2005 study of 12 patients who underwent the procedure under general anesthetic, none were found to have suffered from catheter-related complications. However, they were only able to follow patients for 4.3 months, and complications related to the removal or revision of the PD catheter were not examined as they used a technique where the deep cuffs were placed in preperitoneal space[18]. However, later studies have confirmed the potential benefits of rectus sheath tunneling. For instance, Crabtree et al examined the outcomes of 428 patients who underwent catheter implantations by advanced laparoscopic methods with rectus sheath tunneling and selective prophylactic omentopexy[19]. The mean follow-up period in their study was 21.6 months, and in that time catheter flow obstruction was only found in 16 cases, a rate that is significantly lower than that associated with open and basic laparoscopic implantation. Krezalek et al also confirmed the benefit of rectus sheath tunnel in advanced laparoscopic PD catheter insertion in their study, which found better catheter survival time in patients undergoing the procedure, when adjusting for factors such as previous surgery, CKD stage, and previous operations[9].

Given the positive outcomes associated with rectus sheath tunneling in laparoscopic techniques, and that most peritoneal dialysis catheter insertions in Thailand are performed under local anesthesia, we developed a technique for R-PD insertion using a tunneler for minilaparotomy. In our R-PD technique, the PD catheter was initially inserted via a suprapubic incision; since the incision was above the pelvic cavity, this allowed for accurate placement and reduced the risk of omental wrapping. During rectus sheath tunneling, we carefully inspected the tunnel before inserting the tunneler with the PD catheter. This inspection stage helped prevent inferior epigastric vessel injuries resulted in low rate of bleeding complication in our study. In our R-PD technique, a 4 to 5 cm tunnel was created, and a deep cuff was placed under the anterior rectus sheath. Since the cuff was placed extraperitoneum, the removal process was performed as usual. Although patients who had undergone previous abdominal operations did not experience worse outcomes, the open peritoneal dialysis placement technique was found to be more complicated and tiring for the surgeon[20]. For patients who had undergone previous abdominal operations, the suprapubic incision for the R-PD procedure was placed above the pelvic cavity. This allowed the surgeon to avoid the scars and intra-abdominal adhesions along the scars, which are commonly found in patients who have undergone such abdominal procedures.

The cumulative catheter survival rate in the R-PD insertion patients was 50% and 17% at the 1st and 4nd year, which is slightly low comparing to other studies[21,22]. Our outcomes may relate to natural history of CKD patients in Thailand since 21 patients died from other diseases during follow-up period. Studies from other techniques including laparoscopic techniques have also reported comparable early outcomes[22]. In the R-PD insertion group, catheter dysfunction was found in only 7.5% of patients—one from peritonitis (2.5%) and two (5%) from outflow obstruction—a lower rate than those associated with percutaneous PD insertion[23] and fluoroscopic guided insertion[24], and only slightly higher than the rate associated with advanced laparoscopic with rectus sheath tunnel insertion (3.3% to 4%)[19,21,25]. No leakage was found in patients who underwent R-PD insertion; this may be a direct benefit of the rectus sheath tunnel and the 14-day break in period.

Given study limitations, our study was a descriptive study. We mainly presented the R-PD insertion technique and outcomes in limited number of CKD patients. In addition, given the retrospective review nature of the study, it was impossible to control for confounding and selection bias, as all cases were intentionally assigned to specific surgeons. R-PD insertions were consecutively performed by a single surgeon (PA), which specialized in PD catheter insertion and resulted in low complication rate and high success rate.

Conclusion

The technique of R-PD insertion under local anesthesia was found to be simple, cost effective, and feasible for general surgeons to perform. Our data suggest that adopting the technique of rectus sheath tunneling as detailed herein, could prevent catheter malfunction due to catheter tip migration and pericatheter leakage as well as increase catheter survival rates. Although we were able to present the results in 40 patients, the outcomes were comparable to those associated with advanced laparoscopic techniques. Future studies that include more patients and follow-up over a longer period will no doubt yield valuable data. We propose that this procedure could be encouraged as an alternative to the current peritoneal dialysis catheter insertion technique to improve standard CKD treatment in Thailand and elsewhere.

What is already known on this topic?

Although traditional PD catheter insertion in Thailand which using minilaparotomy technique is simplified, the results still have catheter dysfunction and complications.

What this study adds?

Our study presented novel and simplified technique for PD catheter insertion and its outcome. Due to its outcomes, this technique could be a standard of PD catheter insertion in Thailand.

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Potential conflicts of interest

The authors declare no conflict of interest.

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