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Long-Term Outcomes of Single-Port Laparoscopic Placement of Peritoneal Dialysis Catheter

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Abstract

Introduction: Laparoscopic insertion of peritoneal dialysis (PD) catheter has become a preferred method compared to the traditional open technique for PD catheter insertion. We retrospectively report the outcome of 1-port laparoscopic placement PD catheters in our institution. **Methods:** A total of 263 patients with end-stage renal disease who underwent single-trocar laparoscopic PD catheter insertion during a recent 6-year period were reviewed. Laparoscopic technique involves introducing a PD catheter over a stiff guidewire into the abdominal cavity through a 10-mm laparoscopic port. Pertinent clinical variables, procedural complications, and follow-up outcome were analyzed. **Results:** There were 182 men and 81 women. The mean age was 56 years. Technical success was 95.8%. Catheter occlusion was the most common early complications (<6 months) that occurred in 4 (1.5%) patients. Late complications (> 6 months) including catheter occlusion, cuff extrusion, catheter leakage, catheter migration, infection, and hernia occurred in 5 patients (1.9%), 2 patients (0.8%), 3 patients (1.1%), 3 patients (1.1%), 6 patients (2.3%), and 4 patients (1.5), respectively. Mean follow-up time was 39 $\pm$ 18 months. Catheter survival rate at 1, 2, 3, 4, and 5 years was 96%, 94%, 90%, 85%, and 82%, respectively. **Conclusion:** Laparoscopic PD catheter implantation via a single-trocar utilizing a stiff guidewire technique is feasible and safe. This method can result in low complication and high catheter survival rate.

Keywords

peritoneal dialysis catheter, single port, laparoscopic, dialysis access, peritoneal dialysis

Introduction

Management of patients with end-stage renal failure has evolved considerably over the past decade as peritoneal dialysis (PD) has become a widely used strategy for renal replacement therapy. The popularity of PD is in part due to its role as a primary method of dialysis or as a temporary bridge to renal transplant. Recent studies have shown that PD is associated with increased survival compared to those treated with hemodialysis.[1-4] Successful PD therapy requires a functioning catheter placed in the abdominal cavity to allow unrestricted fluid exchange of the dialysate liquid from the peritoneal cavity.

The laparoscopic approach has been adopted widely in recent years for patients undergoing abdominal surgical procedure due to perceived benefits of less pain, faster recovery, earlier return of bowel function, and shorter hospital stay compared to the traditional open surgery. This evolution in laparoscopic surgery has also led to the development of various minimally invasive techniques for PD catheter insertion as well as management of malfunctioned PD catheters.[5-8]

Although many surgeons described techniques utilizing 2 to 4 laparoscopic ports for PD catheter insertion with excellent treatment outcomes,[8-12] each laparoscopic trocar placement may result in a weak abdominal entry site, whereby fascial defect with subsequently ventral hernia or leakage can occur.[13] To minimize the risk of multiple laparoscopic port placement of PD catheter insertion, several authors have reported techniques utilizing a single-trocar method.[8,14-18] Despite these reports, variation in laparoscopic 1-port techniques and treatment outcome remains notable. In this study, we report our experience of a 1-port laparoscopic method for PD catheter insertion. Technical details and treatment outcome of these patients are discussed.

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Patients and Methods

The clinical records of all patients with end-stage renal failure who underwent laparoscopic PD catheter insertion between December 2009 and June 2015 were retrospectively reviewed. All patients included in this study underwent laparoscopic PD catheter placement, with the intent of using a single-port technique. Patients who underwent open conversion or required additional laparoscopic port placement were also included. Relevant clinical information including demographic characteristics, surgical history, operative variables, catheter-related complications, and follow-up information were obtained from the clinic medical records as well as hospital medical record. Catheter-related complications were classified as early (< 6 months) versus late (> 6 months), and complications were defined as catheter occlusion, cuff extrusion, catheter leakage, catheter migration, catheter infection, exit-site infection, and hernia. Follow-up time was defined as from the time of PD catheter placement to June 2015, time of catheter removal, or patient's death.

Laparoscopic Insertion Technique

A single-port laparoscopic technique for tunneled PD catheter insertion was utilized or attempted in all patients. A double-cuffed PD catheter (Argyle Swan Neck Curl Catheter,; Covidien, Dublin, Ireland) was used for catheter placement in our series. All procedures were performed in the operating room under general anesthesia. Prophylactic antibiotics (cefazolin or vancomycin) and deep venous thrombosis prophylaxis with sequential compression device were administered at the onset of the general anesthetic induction in all patients. The single-port insertion methodology utilized in our series was based on a technique described previously in 2013 by Hwang and colleagues.[8] Briefly, a 10-mm laparoscopic trocar (Visiport Plus,; Covidien) was inserted in the periumbilicus region under the direct visualization of a 10-mm 0° laparoscopic camera (Stryker, Kalamazoo, Michigan). Next the trocar was removed from the laparoscopic port, and carbon dioxide insufflation was performed to achieve pneumoperitoneum with intra-abdominal pressure kept under 12 mmHg during the procedure. Next the laparoscopic camera was introduced via the port for general inspection of the abdominal and pelvic cavity to ensure no significant anatomical challenges such as abdominal adhesions or ventral hernia existed. The patient was placed in steep Trendelenburg position, while the laparoscopic camera was directed superiorly toward the pelvic rim. With steady pressure applied to the trocar in a forward motion, the laparoscope was removed from the port. A 180-cm Amplatz Super Stiff guidewire (Boston Scientific, Natick, MAassachusetts) was inserted in the cuffed PD catheter, which was followed by PD catheter and guidewire insertion into the port. The PD catheter was positioned and maintained in the pelvis, while the guidewire was next removed from the catheter. The patient was next returned to a reverse Trendelenburg position, whereby abdominal contents were allowed to return toward the pelvis. The laparoscopic trocar was next removed over the PD catheter, and the pneumoperitoneum was released from the abdominal cavity. Once the port was removed, the internal cuff of the catheter was positioned above the peritoneum, and the catheter was tunneled above the superficial fascia. The catheter was tunneled in a smooth curved fashion and exits at the upper corner of the anterior rectus fascia incision. Patients with severe abdominal adhesions or anatomical difficulty in whom a single trocar technique was deemed unfeasible or unsafe, PD catheter placement was performed either with additional laparoscopic trocar placement to optimize visualization or open conversion. The catheter patency was ensured by flushing and withdrawing 50 to 60 mL of saline solution through the PD catheter. Heparinized solution was instilled in the catheter which was capped for 1 week before the initiation of PD. Following catheter placement, all patients were evaluated and examined by PD nurses within 4 days following the insertion. Low-volume exchange of dialysate fluid (a maximum of 250 cc) was infused during the first 10 days prior to the initiation of dialysis.

All data are reported as mean $\pm$ standard error of the mean. A Kaplan-Meier analysis was used to determine the PD catheter survival. All statistical analysis was performed using a statistical software program (SAS Institute, Cary, North Carolina).

Results

During the study period, a total of 263 patients (182 males and 81 females) underwent tunneled PD catheter insertion utilizing 1-port laparoscopic technique. The median age at the time of PD catheter insertion was 56 years (range 18-72 years). Demographic data are summarized in Table 1. Forty-five (17.1%) patients had a history of previous abdominal surgery including 23 (8.7%) with hysterectomy, 5 (1.9%) with cholecystectomy, 3 (1.1%) with appendectomy, and 14 (5.3%) with colon resection. Technical success using the 1-port technique was achieved in 252 (95.8%) patients. Two patients required open conversion due to severe abdominal adhesion, and concomitant adhesiolysis was performed with open PD catheter insertion. In 9 (3.4%) patients, additional laparoscopic ports were necessary to either provide enhanced laparoscopic visualization of catheter insertion or ensure procedural safety. No complication related to general anesthesia occurred in our series. Mean operative time was 15 $\pm$ 5.3 minutes (range 10-36 minutes). Six (2.3%) patients were admitted for overnight observation for pain control, while the remaining 257 (97.7%) patients were discharged home as outpatient. No intraoperative complications occurred in our series.

Catheter-related complications were summarized in Table 2. Overall complications occurred in 33 patients or 12.5%. Early and late complications occurred in 12 (4.6%) patients and 23 (8.7%) patients, respectively. The most common adverse event was catheter occlusion in both early and late complication categories, which occurred in 4 (1.5%) patients and 5 (1.9%) patients, respectively. Immediate catheter removal was

Table 1. Patient Demographic and Clinical Variables.

Variables	N = 263
Age, yr, median (range)	56 (24-84)
Sex, male/female	182/81
History of abdominal hernia repair	35 (13.3%)
History of abdominal surgery	45 (17.1%)
Cause of renal failure	
Diabetes nephropathy	135 (51.3%)
Chronic glomerular nephritis	65 (24.7%)
Hypertensive nephritis	33 (12.5%)
Polycystic kidney disease	11 (4.2%)
Interstitial nephritis	8 (3.0%)
Chronic pyelonephritis	5 (1.9%)
Other causes	6 (2.3%)
Laboratory values at the time of PD catheter insertion	
Blood urea nitrogen, mmol/L, mean/SD	39.5 ± 12.6
Serum creatinine, mg/dL, mean/SD	4.5 ± 3.7
Glomerular filtration rate, %, mean/SD	9.5 ± 4.6
Mean duration of operation, min, mean/SD	10 ± 5.3 min
Technical success using the one-port technique	252 (95.8%)
Convert to open PD placement	2 (0.8%)
Convert to two-port laparoscopic catheter placement	6 (2.3%)
Convert to three-port laparoscopic catheter placement	3 (1.1%)

Abbreviation: PD, peritoneal dialysis.

Table 2. Catheter-Related Complications.

Complications	N = 263
Intraoperative complications	0 (0%)
Early complications	
Catheter occlusion	4 (1.5%)
Cuff extrusion	2 (0.8%)
Catheter leakage	1 (0.4%)
Catheter migration	3 (1.1%)
Catheter infection/peritonitis	2 (0.8%)
Exit-site infection	0 (0%)
Hernia	0 (0%)
Late complications	
Catheter occlusion	5 (1.9%)
Cuff extrusion	2 (0.8%)
Catheter leakage	3 (1.1%)
Catheter migration	3 (1.1%)
Catheter infection/peritonitis	4 (1.5%)
Exit-site infection	2 (0.8%)
Hernia	4 (1.5%)
Overall complications	33 (12.5%)
Postoperative mortality	0 (0%)

performed on all patients with exit-site infection or peritonitis. Tunneled hemodialysis catheter insertion was performed in patients with peritonitis who were transitioned to hemodialysis. Abdominal wall hernia developed in 4 (1.5%) patients following PD initiation. Two (0.8%) patients underwent laparoscopic hernia repair with prosthetic mesh, and PD catheter was revised at the time of hernia repair. One (0.4%) patient developed unilateral inguinal hernia while 1 (0.4%) patient developed bilateral inguinal hernias. All of them underwent successful inguinal laparoscopic inguinal herniorrhaphy without complications. All patients were able to resume peritoneal dialysis following laparoscopic ventral hernia repair. There was no perioperative mortality associated with the PD catheter procedure.

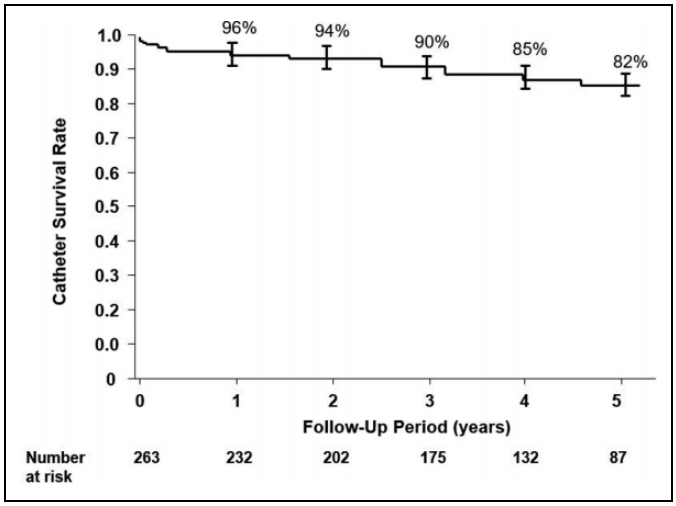

Figure 1. Kaplan-Meier analysis of peritoneal dialysis (PD) catheter survival following laparoscopic placement.

Mean follow-up period was 39 ± 18 months with ranges between 3 and 85 months. Forty-six (17.5%) patients died during the follow-up period, all due to other medical problems. Six (2.3%) patients showed renal function improvement, and PD catheters were removed as they no longer required PD. Three (1.1%) patients received renal transplant following PD catheter insertion, and their PD catheter was removed. Figure 1 summarizes catheter survival during the study period, and mean catheter survival time was found to be 4.22 ± 0.23 years. Catheter survival rate at 1, 2, 3, 4, and 5 years was 96%, 94%, 90%, 85%, and 82%, respectively.

Discussion

Advances in laparoscopic surgical technique over the past 2 decades have significantly transformed our ability to provide dialysis access care to patients with end-stage renal failure. First introduced in the 1980s,[19] laparoscopic placement of peritoneal dialysis catheter has been shown to have many advantages over open or percutaneous insertion techniques, including lower incidences of visceral injury, ability to inspect the abdominal cavity, and capability to perform concomitant procedures such as adhesiolysis.[1,3,8,19] While most of reported series on laparoscopic peritoneal dialysis catheter insertion utilizes 2 to 4 laparoscopic ports,[8-12] our study is notable as it represents the largest series of patient cohorts treated with a single-port insertion technique.

Although laparoscopic techniques of PD catheter implantation have been widely reported previously,[5,7,9-12,16] significant variations are notable among these laparoscopic techniques.

Many authors utilized 2 or 3 ports in their laparoscopic techniques in which 1 port was used to place the laparoscopic camera, while other ports were utilized to insert the PD catheter.[9,12,13] One clear benefit of the laparoscopic approach, in contrast to open insertion technique, is that PD catheter is placed in the pelvis under direct laparoscopic guidance. A potential drawback of the laparoscopic technique is the need for general anesthesia, a consideration that may pose added physiologic stress to patients with underlying end-stage renal disease. Additionally, basic laparoscopic equipment along with fundamental laparoscopic skills are needed for surgeons to perform this minimally invasive procedure. A comparative study, which randomized laparoscopic and open PD catheter insertion demonstrated that the laparoscopic approach, although more time consuming, did not result in superior clinical outcomes compared to the open technique.[20] One explanation regarding this finding is that a 3-port laparoscopic technique was used for catheter insertion, which could account for potential abdominal wall hernia or leakage secondary to multiple laparoscopic port placement.

Advances in laparoscopic techniques have led to numerous reports describing various 1-port PD catheter insertion techniques, as these authors postulate potential benefits of expeditious insertion time with less complications including insertion site leakage or abdominal wall hernia.[14-18] The method utilized in our series was modified based on the technique described previously in which a double-cuffed PD catheter is introduced via a single laparoscopic port over an Amplatz Super Stiff guidewire.[8] The Amplatz guidewire, a commonly utilized wire in endovascular interventions, provides 2 important mechanical features that are critical in facilitating laparoscopic insertion of a PD catheter. First, the main wire body is extremely stiff which, when placed inside a PD catheter, provides a rigid catheter-wire entity. This in turn creates a stable catheter pushability that enables the physician to introduce the catheter toward the pelvis via the laparoscopic port. Second, the distal guidewire end has a very soft nontraumatic tip, which enables the tip of the catheter to be positioned in the pelvis without causing undue wire-related perforation or injury to visceral organs in the abdominal cavity. An important modification in our technique, compared to the original published report, is that we place the patient in a steep Trendelenburg position (>60°) while the PD catheter is aimed toward the pelvis, thereby allowing a cephalic movement of the bowels away from the pelvis. This maneuver vacates the bowels from the pelvic floor which enables the PD catheter to be positioned at the pelvic floor. Once the PD catheter is positioned in the pelvis, the Amplatz wire is removed followed by placing the patient in a reverse Trendelenburg position that allows caudal movement of the bowels back to pelvis. This maneuver in the patient's body position allows catheter fixation in the pelvis by the surrounding bowels. The principle steps described in our technique incorporating the Trendelenburg position and utilizing an Amplatz stiff wire to support the PD catheter insertion are simple to perform which does not require advanced laparoscopic skills. In contrast to other 1-port insertion techniques which utilize a 16 French peel-away introducer sheath approach with serial dilation,[14] we believe our technique is safer due to the nontraumatic nature of catheter insertion method into the pelvis.

Malfunction of PD catheter can occur frequently with a reported incidence ranging from 8% to 44%.[1,13,21,22] Examples of catheter malfunction include catheter kinking, malposition, migration, or obstruction secondary to omental wrapping, fibrin formation, or intraperitoneal adhesions.[1,3,13,21,22] However, catheter infection remains the leading cause of morbidity, and catheter removal remains the mainstay of treatment for the infection complication.[3,20] Risk factors for catheter-related infection include concurrent body infection, malnutrition, coexisting immunosuppressive disorder, and lack of sterile technique during catheter implantation.[8,23-25] Due to the physiologic compromise of these patients with underlying renal insufficiency, strict infection control with diligent aseptic techniques must be followed during both catheter implantation and daily PD fluid exchange process to minimize bacterial contamination which can result in peritonitis, overwhelming sepsis, or even death. In our series, infectious complications including exit-site infection and peritonitis occurred in 6% and 7%, respectively. This finding is consistent with other reports, whereby exit-site infections ranged from 5% to 18% and peritonitis ranged from 7% to 26%, respectively.[8,23-27] The need for PD catheter replacement in our series was 7% which compared favorably with other reports in which replacement rates ranged from 9% to 19%.[16,17,24-27] Although some studies have noted adhesions from prior abdominal surgery may pose technical challenges for laparoscopic PD catheter placement,[24,25] we do not believe prior abdominal operation represents a contraindication for laparoscopic approach because direct laparoscopic visualization of the abdominal cavity enables the surgeon to place the catheter in a adhesion-free region of the pelvic compartment.

Abdominal wall hernia including umbilical or trocar site hernia occurred in 4 (1.5%) of our patients following laparoscopic PD catheter insertion. These types of hernias occur commonly in these patient cohorts due to concomitant risk factors including hypoalbuminenia, malnutrition, or chronically elevated intra-abdominal pressures due to PD.[4,13,27] The incidence of abdominal wall hernia following PD catheter placement in our series compared favorably with reported studies in which the incidence of hernia can reach as high as 12%.[4,13,20,26,27] Several surgical variables can contribute to the formation of trocar site hernia which include size of the laparoscopic port, preexisting fascial defect, inadequate fascial closure techniques, and obesity.[4,13,24,26,27] Despite these known etiological variables, many authors reported wide disparity with regard to trocar site hernia. Tonouchi and associates noted an incidence of trocar site hernia between 0.65% and 2.8% for patients undergoing various types of general laparoscopic procedures.[28] This finding was consistent with reports by Kadar and colleagues who demonstrated a trocar site hernia of 3.1% using 12-mm laparoscopic ports in gynecological procedures.[29] These findings are in sharp contrast with studies regarding

patients who underwent PD catheter insertion, whereby trocar site hernia generally ranged between 3% and 8%.[1,19,24,27]

Leakage at the catheter insertion site can be an inconvenient challenge to manage as it can prevent the use of the PD catheter for adequate peritoneal dialysis. Most authors recommend a 2- to 3-week delay before the PD catheter is used for peritoneal dialysis to reduce the incidence of insertion site leakage.[5,15,27] The catheter site leakage rate in our series was low which was 1.5%, and we attributed to meticulous insertion technique as well as using a single port for catheter insertion. Several authors have described various technical modifications to reduce this complication, which includes delaying the wait period before commencing peritoneal dialysis, lengthening the musculofascial tunnel for catheter insertion, or reducing the size and diameter of trocar number.[27,30,31] In our technique, the cuff segment of the PD catheter is embedded just above the fascia which is closed using interrupted sutures. We believe this technique is adequate in preventing leakage from the insertion site.

There are undoubtedly several limitations in our study. The perceived benefit of our laparoscopic technique was evaluated in the absence of a control or open surgical group. In addition, our 1-port technique was not compared with other published laparoscopic approaches which utilized 2 or 3 laparoscopic ports. Consequently, any conclusion regarding technical advantages based on this 1-port methodology is not based on objective comparison. Additionally, the retrospective nature of our study encompassed certain selection bias in terms of those who received laparoscopic PD catheter insertion. Finally, the heterogeneous comorbidities and causative factors of end-stage renal failure underscore the clinical complexity of these patient cohorts which undoubtedly affected surgical treatment outcome.

In conclusion, our series demonstrated that 1-port laparoscopic technique for PD catheter insertion is safe, feasible, and results in a low incidence of catheter-related complications such as catheter infection or hernia. This minimally invasive catheter insertion technique can be performed with a relatively short operative time and quick recovery period. Further follow-up study on the long-term outcome using this technique can validate its role in the management of laparoscopic PD catheter placement.

Declaration of Conflicting Interests

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