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Outcomes of Laparoscopic Peritoneal Dialysis Catheter Placement Using an Optimal Placement Technique

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ABSTRACT

Background: Peritoneal dialysis (PD) is a widely employed renal replacement modality. A prospective study was conducted to determine the short-term and midterm outcomes and complication rates associated with a standardized optimal laparoscopic peritoneal dialysis catheter placement technique.

Methods: All patients undergoing laparoscopic PD catheter placement by one surgeon using our standardized method over a 5-year period were entered into a prospective database. Patients were evaluated preoperatively and postoperatively through office visits. Development of complications was assessed using follow up telephone or mail surveys.

Results: A total of 100 patients with a mean age of 56 years underwent laparoscopic PD catheter placement over the 5-year study period. In total, 103 laparoscopic PD catheter placement attempts were made in 100 patients. Placement was successful in 98 (95.1%) attempts and no placement required conversion to an open operation. Omentopexy was performed in 82 (83.7%) patients. There was no mortality reported within 30 days of the index operation. For patients who successfully underwent laparoscopic PD placement, early complications developed in 9 (9.2%) patients, of which 6 (6.1%) complications were directly related to the PD catheter. Midterm complications developed in 25 (25.5%) patients. Complication-related catheter repositioning was required for 12 (12.2%) catheters and catheter-related complication removal was required for 18 (18.4%) catheters.

Conclusion: Laparoscopic placement of PD catheters can be successfully performed using a combination of described standardized laparoscopic maneuvers for optimal placement resulting in acceptable perioperative and short and midterm complication rates with negligible mortality rates.

Key Words: Peritoneal dialysis, PD catheter, Laparoscopy, Catheter placement.

INTRODUCTION

Peritoneal dialysis (PD) was first reported as a treatment strategy for end stage renal disease (ESRD) in 1976.[1] With advances in minimally invasive surgical techniques over the last 2 decades and ongoing improvements in PD capabilities, this option has become an increasingly recommended method for renal replacement therapy for management of ESRD. The annual incidence of ESRD in the United States has increased from 77,003 to 124,675 patients per year from 1996 to 2016.[2] In the United States, the most common currently pursued treatment strategy for ESRD is hemodialysis (HD). In 2016 HD was employed in 89% of Americans newly diagnosed with ESRD.[2] Although PD has become an accepted method for renal replacement therapy it was only used for approximately 10% of new patients requiring dialysis in 2016.[2]

A leading advantage of peritoneal dialysis is a decreased medical cost for renal replacement therapy.[15] Peritoneal dialysis can also be performed in the patient's own home thus alleviating the need for multiple trips per week to a dialysis center. The materials for PD are easily portable allowing patients to travel without accruing additional inconvenience of coordinating dialysis. Patients on PD also

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have fewer dietary restrictions compared to those on HD. The literature has demonstrated an improved perceived quality of life in PD patients compared to those treated with HD as PD patients were found to be 1.5 times more likely to be satisfied with their dialysis therapy than patients undergoing HD.[3] PD patients also rated their care higher in many different categories surveyed than HD patients.[3] For patents eligible for both PD and HD, peritoneal dialysis has been shown to have a significantly lower primary failure rate, 4.6% versus 32%, and a lower access intervention rate of 2.5 versus 3.1 interventions in the first 10.3 years after dialysis initiation.[4] Disadvantages of PD compared to HD include the fact that PD must often be performed daily and that PD entails an external abdominal catheter, which may be cosmetically unappealing for certain patients. Additionally, well-described complications of PD, such as peritonitis, outflow obstruction, leakage, and migration hinder PD selection for therapy.[5] Laparoscopic placement techniques have been refined to lower the risk for complications and drawbacks of PD. These techniques include omental fixation,[5–7,17] preperitoneal tunneling,[8,16,17] adhesiolysis,[5,16] paramedian placement,[9] and catheter fixation.[10] A PD catheter placement technique incorporating all of the above techniques to standardize catheter placement has been described with early promising feasibility results.[18,19] The primary objective of this study is to evaluate the short-term outcomes of patients undergoing laparoscopic PD catheter placement using a described techniques for optimal placement. Secondary analysis also evaluates midterm outcomes. We report our initial experience with 103 laparoscopically placed peritoneal dialysis catheters focusing on short-term and midterm outcomes.

METHODS

A prospective cohort study was conducted in adult patients undergoing laparoscopic placement of PD catheters at a single institution from August 2007 to December 2012. All patients were entered into a prospective database established in 2007. Clinical research protocols to evaluate and review charts of patients undergoing PD catheter placement was approved by the Institutional Review Board of the institution. All patients undergoing attempted laparoscopic placement of PD catheters from August 2007 through December 2012 were evaluated for this study to assess treatment-related complications and outcomes that developed within 30 days (early) or known complications occurring more than 30 days (mid) after placement of the PD catheter. Over the study period, a total of 103 laparoscopic PD catheter placements were attempted with all catheters placed by a single surgeon with fellowship training in minimally invasive surgery.

Data recorded included patient age, sex, comorbidities, etiology of renal failure, and past abdominal surgical history. All complications associated with the PD catheter or resulting from the surgical operation were meticulously sought and recorded. For patients undergoing catheter removal, the underlying reason for removal and renal replacement therapy pursued were documented. The primary end point was a 30-day catheter-related complication rate. Secondary end points included 30-day mortality, hospital length of stay, operative time, and overall morbidity including midterm complications.

All PD catheter placements during the study period were performed by the same surgeon in a standardized fashion as described in our previous feasibility study publication.[19]

Peritoneal dialysis catheters were flushed within 5–7 days from surgery and use for dialysis was left to the discretion of the dialysis center and nephrologist. To improve our knowledge of midterm outcomes and find any additional problems, patients were contacted either by phone interview or by mail survey with a mean follow-up of 24.4 months to confirm the status of their catheter or incidence of complications.

Statistical Analysis

Baseline data are presented as mean (range) and number (%). Pearson's χ^2 test for association was used to calculate P values if every expected cell frequency was greater than or equal to five. If any expected cell frequency was less than five, the Fisher's exact method was used to calculate P values. A significant level of .05 was considered statistically significant, and 95% confidence intervals were calculated when applicable.

RESULTS

A total of 103 catheter placement attempts were made in 100 patients. Catheter placement was unsuccessful in 5 (4.9%) attempts due to active peritonitis (n = 2), dense adhesions (n = 2), or ascites (n = 1) precluding safe and optimal placement. The five unsuccessful attempts were not included in the statistical analysis for this study. Among the 98 successful catheter placements, 63 (64.3%) were male and 35 (35.7%) were female. The mean age was 56.5 years (range 25–88 years). The American Society of Anesthesiologists (ASA) score was either 3 (n = 43, 43.9%) or 4 (n = 55, 56.1%) for all

patients. All catheter placements were performed laparoscopically and 82 (83.7%) were completed on a same-day surgery outpatient basis. Mean operative time was 31.2 minutes (range 13–77 minutes) and the mean postoperative length of stay was 0.39 days (range 0–10 days). The primary etiology of renal failure necessitating renal replacement therapy included hypertension alone, diabetes alone, a combination of diabetes mellitus and hypertension, polycystic kidney disease, autoimmune sources (lupus, multiple myeloma, or IgA nephropathy), idiopathic (congenital, glomerulonephritis, and focal segmental glomerulosclerosis), neurogenic bladder, drug related (antibiotic or lithium induced), hypotension, pyelonephritis, and renal cell cancer. Sixty-two patients (63.3%) had previously undergone abdominal surgery including but not limited to splenectomy, renal transplant, laparoscopic sleeve gastrectomy, hernia repair, ulcer repair, hysterectomy, colpopexy, and tubal ligation. Eleven (11.2%) patients had a history of previous PD catheter placement. Patient characteristics, including etiology of renal failure, are summarized in **Table 1**.

In total, 82 (83.7%) omentopexies were completed in conjunction with PD catheter placement at the time of surgery. For cases without omentopexy, the omentum was either densely adherent to a previous scar or too small to reach the pelvis. Additional procedures at the time of catheter placement, excluding omentopexy, were performed in 22 (22.4%) patients. These most commonly included eight adhesiolysis and eight hernia repairs, (8.2% each). Other additional procedures performed include removal of a previous PD catheter (4, 4.1%) and tissue biopsy (3, 3.1%) (2 liver, 1 peritoneal).

Table 1.
Descriptive Statistics of Patients with Successful Catheter Placement

Sex	
Male	63 (64.3%)
Female	35 (35.7%)
Age	
Mean (range)	56.5 (25–88)
Etiology of renal failure	
Hypertension and diabetes	37
Hypertension	26
Idiopathic	8
Polycystic kidney disease	7
Autoimmune	7
Diabetes	6
Hypotension	2
Neurogenic bladder	2
Medication induced	2
Pyelonephritis	1
Operative time (minutes)	
Mean (range)	31.2 (13–77)
Additional procedures	
Yes:No	22:76
Omentopexy performed	
Yes:No	82:16
Previous major abdominal surgery	
Yes:No	62:36
Short-term complication	
Yes:No	9:89
Midterm complication	
Yes:No	25:73
Complication related catheter removal	
Yes:No	18:80

Primary End Point

Complications within 30 days of catheter placement occurred in 9 patients (9.2%), 6 (6.1%) were catheter-related complications. The six catheter-related complications included 4 (4.1%) patients with catheter malfunction caused by intraperitoneal adhesions and two (2.0%) patients who developed hemoperitoneum within 30 days of catheter placement. All four patients with adhesion-related catheter malfunction underwent laparoscopic revision of the catheter to restore flow. One patient with hemoperitoneum had their catheter removed for recurrence of hemoperitoneum beyond 30 days postop. The other patient with hemoperitoneum developed insufficient dialysis requiring eventual catheter removal. The 3 noncatheter-related complications included two patients that experienced postoperative urinary retention that spontaneously resolved and a third patient who developed hypervolemia requiring inpatient admission.

Secondary End Points

Midterm complications beyond 30 days after laparoscopic PD catheter placement were detected in 25 (25.5%) patients, 23 (23.5%) of which were catheter related. Noncatheter-related complications included development of hernia (n = 1), and pleural effusion (n = 1). The 23

catheter-related complications consisted of 14 (14.3%) infections either of the catheter or peritonitis, 8 (8.2%) instances of insufficient flow due to adhesions, and 1 (1.0%) case of recurrent hemoperitoneum. All eight patients with insufficient flow underwent revision or repositioning procedures, with three achieving successful restoration. No patients were lost to short-term follow-up during the study period.

A subset analysis identified a total of 62 patients with a history of prior abdominal surgery that underwent successful placement of a PD catheter. In this group, 21 (34%) patients experienced either short-term or midterm catheter-related complications during the study period. All 6 (100%) of the short-term catheter-related complications occurred in patients with a prior history of abdominal surgery, whereas 15 (65.2%) of the 23 midterm catheter-related complications were also in this subgroup. Patients with no prior abdominal surgical history (n = 36) accounted for no short-term catheter-related complications and for 8 (34.8%) of the midterm catheter-related complications. The relative risk of developing short-term and midterm complications after having a previous abdominal surgery were 4.65 and 1.23, respectively, this showed a trend but did not demonstrate statistical significance ($P > .05$).

Patients who had additional surgery at the time of catheter placement have almost seven times (RR = 6.91) (P value $<.05$) the relative risk of having complications within 30 days of catheter placement compared to the patients who did not have additional surgery at the time of catheter placement. Patients who had omentopexy had 0.24 relative risk (P value $<.05$) of developing complications within 30 days of catheter placement compared to those who did not have omentopexy.

Association between patients that had past PD catheters and had complications within 30 days of catheter placement is statistically significant (RR = 6.33) (P value $<.01$). Our findings demonstrate up to 84.20% of complications within 30 days of catheter placement may be associated with factors related to history of previous PD catheters. The relative risk and attributable proportion for short-term and midterm complications are demonstrated in **Table 2**. Risk for catheter infection and catheter repositioning are seen in **Table 3**.

DISCUSSION

PD has emerged as a preferable alternative to the more traditional modality of hemodialysis for renal replacement therapy. PD catheter complications have been well documented. These include catheter tip migration, omental wrapping or entrapment, flow limitations, and catheter infections, among others. Laparoscopic techniques for placement of PD catheters has been shown to have many advantages including lower incidence of catheter revision/replacement, a shorter time to use,[11] lower rates of hemorrhage, inadvertent organ damage, and incisional hernias.[12,13] With laparoscopic placement, there is opportunity to proactively address potential problems that reduce catheter function. This includes catheter tip migration,[10] omental entrapment, and peritoneal adhesions.[5] Additionally, PD catheters placed laparoscopically offer a 97.8% immediate successful function rate compared to 80% successful function rate in those placed by traditional blind guidewire technique.[11]

Previously, we have reported a protocol that combines specific reproducible techniques for placement of peritoneal dialysis catheters.[19] Through our process of ensuring that the same surgeon performed all surgeries and managed all perioperative care, we were able to meticulously track and ensure maximal capturing of complications. We assessed our results with those previously reported in the literature and found that our technique offers comparable results.

Examination of our results revealed hemoperitoneum occurred in 2%[2] of patients during the short-term period. The first patient had recurrence of intra-abdominal bleeding that required catheter removal 6 weeks after the index placement. At the removal operation, findings suggested the bleeding was secondary to peritoneal irritation and no specific vessel source of bleeding was identified. This bleeding was consistent with and attributed to uremic coagulopathy. The other patient had transient bleeding in the short-term period and subsequently developed insufficient dialysis requiring removal of the catheter 9 weeks after initial placement. In a study conducted by Crabtree and colleagues[6] using comparable techniques, no patients developed intraperitoneal hemorrhage. Our study demonstrated a rate of 2%, which may be related to the general medical condition of the patients rather than surgical technique and is well within the inherent risk of bleeding in patients with uremic coagulopathy.

In the combined short-term and midterm, 12 catheters required revision due to flow obstruction, malfunction, or adhesions. Four required revision within 30 days of placement, the remaining 8 catheters required revision more than 30 days after placement. Our flow obstruction rate of 12.2% is greater than the 30.7% flow obstruction rate reported by Crabtree et al.[6] It should be noted that we

Table 2.
Relative Risk of Short- and Midterm Complications by Additional Procedures, Omentopexy, Previous Major Abdominal Surgery, Past PD Catheters

	Short-term Complications		Midterm Complications	
	Relative Risk (95% Confidence Interval)	*P* value	Relative Risk (95% Confidence Interval)	*P* value
Additional procedures				
No	1		1	
Yes	6.9 (1.9–25.4)	< 0.05	1.3 (0.7–2.8)	0.43
Omentopexy				
No	1		1	
Yes	0.2 (0.1–0.8)	< 0.05	1.4 (0.5–4.2)	0.52
Previous major abdominal surgery				
No	1		1	
Yes	4.7 (0.6–35.6)	0.14	1.2 (0.6–2.6)	0.57
Past peritoneal dialysis catheter				
No	1		1	
Yes	6.3 (2.0–20.1)	< 0.05	1.1 (0.4–3.0)	0.89

Table 3.
Relative Risk of Catheter Infection and Catheter Removal by Additional Procedures, Previous Major Abdominal Surgery, Reposition

	Catheter Infection		Catheter Removal	
	Relative Risk (95% Confidence Interval)	*P* value	Relative Risk (95% Confidence Interval)	*P* value
Additional procedures				
No	1		1	
Yes	1.0 (0.2–4.4)	0.99	1.1 (0.7–1.7)	0.70
Previous major abdominal surgery				
No	1		1	
Yes	1.2 (0.3–4.4)	0.82	1.1 (0.7–1.7)	0.57
Reposition				
No	1		1	
Yes	2.3 (0.5–9.6)	0.27	1.3 (0.8–2.1)	0.32

attempted placement in all comers as PD offers a lifeline to our patients and believe attempted placement is warranted. This is reflected in our 5 (4.9%) unsuccessful placement rates. Liberal patient selection, including a high number of patients with pervious surgical history may explain our higher flow obstruction rate. Of the 12 revisions performed, 11 successfully restored flow. Three of the 11 catheters were eventually removed due to infection after flow had been restored. Another two catheters were removed for insufficient dialysis and patient preference despite a functioning catheter. Five catheters had no subsequent complication after successful revision. A final catheter was removed with renal transplantation. A single patient (1/98) underwent unsuccessful revision of the catheter secondary to adhesion-related malfunction resulting in a removal rate due to adhesion of 1%. This is comparable to the 0.7% adhesion-related removal rate reported elsewhere.[6]

There were 14 infections including both peritonitis and subcutaneous catheter infections. Our infection rate of 14.3% is comparable to infectious complication rates of 11%–13% reported in the literature.[14] All infections in our study occurred greater than 30 days postoperatively resulting in no short-term infectious complications. Given that none of the infections occurred within 30 days of placement, we attribute these infections to complications of peritoneal dialysis rather than complications of surgical catheter placement or operative technique. A single subcutaneous catheter infection was amenable to antibiotic treatment alone. The remaining 13 catheters required removal resulting in an overall catheter removal rate of 13.3% for infectious causes, none in the short term.

An interesting association was observed between history of previous abdominal surgery and complication after laparoscopic PD catheter placement. All 6 short-term catheter-related complications (100%) (2 hemoperitoneum and 4 flow failure due to adhesions) and 15 of the 23 (65.2%) midterm catheter-related complications developed in patients with a history of previous abdominal surgery. A total of 61 patients in our study successfully underwent PD catheter placement with a history of previous abdominal surgery, 21 of these patients (34%) experienced either short-term or midterm catheter-related complications during the study period. This is compared to 8 (20.5%) patients without history of abdominal surgery that experienced either short-term or midterm complications.

It was also noted that 18 catheters were removed for catheter-related complications, 10 (55.6%) had a previous history of abdominal surgery and 8 (44.4%) did not have prior abdominal surgical history. Examining all cause catheter removal, we found that 53.7% of patients with a history of prior abdominal surgery ultimately needed catheter removal versus 47.7% eventual removal seen in patients with no prior history of abdominal surgery (RR = 1.13) ($P > .05$). Although not statistically significant, one potential reason for this finding is that prior abdominal surgery leads to the presence of adhesions that may adversely affect catheter function. It should also be noted that this data reflects all cause removal, including catheters removed for patient preference, improvement in renal function, patient decision to pursue HD, and renal transplantation. Additionally, 5 attempted catheter placements during the study period were unsuccessful, 3 of these attempts were in patients with previous abdominal surgery, likely due to the fact that that patients with a history of abdominal surgery may be at higher risk for hostile abdomen or anatomy precluding successful PD catheter placement.

In a subset analysis, examining the short-term complications only, our data also demonstrate a statistically significant increased risk of short-term complications in patients who underwent an additional procedure at the time of PD catheter placement. In our series, additional surgical procedures were performed at the time of catheter placement in 22 patients. Of patients who underwent an additional procedure at the time of PD catheter placement, 12 patients (54.5%) ultimately underwent catheter removal, however, only 6 (27.3%) removals were due to catheter-related complications. Additional procedures performed included extensive adhesiolysis, hernia repair, removal of the previous PD catheter, or biopsy. Additional procedures at the time of catheter placement did not reach statistical significance as a risk factor for catheter infection or need for catheter removal ($P > .05$). Similarly, a history of prior abdominal surgery or catheter repositioning were not identified as statistically significant risk factors for infection or need for catheter removal ($P > .05$). These findings are consistent with other reports in the literature.[6] Furthermore, with a relative risk of 0.2, performance of omentopexy demonstrated a protective impact on the development of short-term complications. As we performed omentopexy selectively based on intraoperative assessment of omental mobility, the magnitude of a protective impact is difficult to quantify and is a potential area for further research.

Strengths of the current study include the prospective enrollment of consecutive patients undergoing laparoscopic placement of PD catheters with an identical uniform surgical technique and perioperative care provided by one single surgeon. The meticulous nature of data collection and capturing of complications aids as a strength of this study when assessing the outcomes data. No patients were lost to follow-up within the first 30 days of catheter placement in accordance with assessing the primary outcome of the study. Limitations include lack of a control group, although we are able to compare our outcomes to other outcomes published in the literature. Additional limitations include the lack of midterm follow-up maximized at 5 years and even shorter duration of time for patients undergoing surgery later in the study. Optimal follow-up is inherently difficult in this study population often burdened with multiple significant comorbidities and patients may change institutions and potentially seek transplant evaluation elsewhere. Follow-up for midterm complications was not obtained at the same time interval for all patients. Data reported are only on known outcomes, which is not necessarily reflective of the entire study population as this is a difficult population to study

long-term due to high mortality and high loss to follow-up rates. As our data are based on a single surgeon experience, similar results may not be achieved by other surgeons. A multiprovider or multicenter trial would be necessary to improve the external validity of our results.

In conclusion, we report the short-term and midterm outcomes of patients undergoing laparoscopic peritoneal dialysis catheter placement. This is the only study reporting short-term and midterm outcomes for the specific PD catheter placement technique described by our group in a previous feasibility study.[19] Our data demonstrate that having a history of abdominal surgery or undergoing simultaneous surgical procedures places a patient at substantially higher relative risk of developing short-term peritoneal dialysis catheter-related complications. As this study was not designed to examine PD catheter placement in patients with abdominal surgical history, additional questions still remain about this relationship and warrant further research.

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