



Outcomes of laparoscopic and open CAPD catheter placement: A single-center experience[☆]



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ABSTRACT

Background: Continuous Ambulatory Peritoneal Dialysis (CAPD) catheter placement is typically a straightforward surgical procedure performed on chronically ill patients with end-stage renal disease (ESRD). Post-operative outcomes and reoperative rates vary greatly in the medical literature. We report our experience using both minimally invasive and open techniques in placing CAPD catheters and offer our surgical outcomes.

Methods: This study is an IRB-approved, retrospective review (2005–2018) of all patients undergoing CAPD catheter placement at Mayo Clinic-Rochester. Analysis focused on specific patient outcomes, including early (<30 days) versus late (≥30 days) complication and reoperation rates.

Results: A total of 173 patients with ESRD (mean ASA score = 3.1) underwent laparoscopic (n = 22) and open (n = 151) CAPD catheter placement (mean follow-up = 309 days; range: 1–3497 days). The total index operation complication rate was 41%. The total index reoperation rate was 37% and was similar in open and laparoscopic approaches. CAPD catheters malfunctioned in 19 patients (11% of total) and each underwent reoperation. CAPD catheter infections occurred in 30 patients (17% of total), and 24 required reoperation; 6 patients were treated successfully with antibiotics. CAPD catheter migrations occurred in 21 patients (12% of total) and all underwent reoperation.

Conclusion: Although CAPD catheter placements in patients with ESRD are technically easy to accomplish, the long term outcomes suggest as many as one in three patients will struggle with catheter function or infection. This study has led to changes in our technical CAPD catheter placement procedures, as well as the post-operative patient care algorithm.

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Introduction

End-stage renal disease (ESRD) is increasing in the United States with over 730,000 patients suffering from this affliction. As the prevalence of ESRD has increased and the wait list for kidney transplants lengthens, so too has the demand for renal replacement therapy. Continuous ambulatory peritoneal dialysis (CAPD) has become increasingly popular worldwide [1]. The modern catheter placement technique was first established as a safe method in 1968 by Tenckhoff et al.; by 1980, CAPD had become a widespread form of renal replacement therapy in the United States [2–4]. While patient outcomes and overall effectiveness of CAPD and hemodialysis are similar, peritoneal dialysis (PD) provides an important edge in early residual renal preservation [5–7]. It also provides an advantage in treatment satisfaction and overall patient happiness [8,9]. This is largely

attributed to increased patient independence as CAPD can be performed in the home, in contrast to the multiple patient visits per week typically required by hemodialysis [8,9].

The majority of recent CAPD catheter placement research has focused on comparing the outcomes for techniques and equipment. In particular, many studies have examined the outcomes of the laparoscopic vs. open technique, and whether the type of catheter (straight, curled, number of cuffs, etc.) affects patient outcomes [10,11]. While individual studies offer conflicting results on each of these topics [10, 12–24] meta-analysis review studies have offered important insights. Xie et al. found that there was no significant advantage with either the laparoscopic or open method in regards to surgical outcomes [2]. Though the open technique was found to be faster, the authors suggested that the visibility that the laparoscopic technique allows makes the choice between the two methods ultimately the surgeon's preference [2,25]. While Hagen et al. released a large meta-analysis with similar results, their work also suggested that a laparoscopic approach has a better one-year catheter survival rate with less chance for catheter migration [4]. With the recent addition of a second surgeon performing laparoscopic CAPD catheter placement within our institution, we aimed to examine the surgical outcomes of these complex patients.

Abbreviations: ESRD, End-stage renal disease; CAPD, Continuous ambulatory peritoneal dialysis; PD, Peritoneal dialysis; ASA, American Society of Anesthesiologist.

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Materials and methods

With Institutional Review Board approval, a retrospective chart review was performed on all patients undergoing either open or laparoscopic peritoneal dialysis catheter placement by two staff surgeons at the Mayo Clinic (Rochester, MN) from May 2005 to March 2018. The variables that were collected were age, gender, body mass index (in kg/m²), preoperative anesthetic risk assessment- American Society of Anesthesiologists score (ASA), operative time, overnight hospitalization, death rate, and follow up. Outcome measures compared laparoscopic versus open approaches and specifically looked at patients who required reoperation. Length of stay, postoperative date of complication appearance (leak, catheter migration, catheter malfunction, and infection), duration of hospitalization, and reoperation rate were analyzed. Reoperation was classified into three categories: catheter removal, catheter reposition, and catheter replacement. Follow-up data was obtained through retrospective review of the medical record through postoperative return visits.

Laparoscopic Approach

A flank incision is created for the camera port, a pneumoperitoneum is generated via an open Hassan technique and the abdomen explored. One or two 5-mm lateral ports are placed and adhesions lysed and/or omentum tacked away from the pelvis as is necessary. A transverse incision is generated 1 cm inferior and lateral to the umbilicus. The curved, single cuff catheter is then tunneled through this incision, slid along the anterior aspect of the posterior rectus sheath, and entered into the peritoneum caudal to the arcuate line of Douglas. The catheter is then placed using laparoscopic graspers to reside in the pelvis near the top of the bladder posterior to the symphysis pubis. If the omentum extends to the bladder (uncommon), the distal omentum is moved cephalad and is sutured to the anterior abdominal wall tacking it away from the pelvis and the catheter tip (omentopexy). The proximal end is tunneled in the fatty tissue to exit the skin in the right side of the abdomen. No skin stitch is used.

Open Approach

A transverse skin incision is created over the rectus muscle at the level of the umbilicus. Dissection is carried posteriorly to identify and incise the anterior rectus fascia. Rectus muscle fibers are separated, exposing the posterior rectus fascia. In this fascia, a pursestring is placed using a 3-0 Prolene suture. At the center of the pursestring the fascia is opened, and the peritoneal cavity entered. A curved single-cuff peritoneal dialysis catheter is directed toward the pelvis, and the pursestring is secured around the catheter. The catheter is then tunneled to a site approximately 2 cm below the skin incision. The catheter is secured to the skin with a nylon suture.

Both procedures were performed under general anesthesia utilizing intra-operative instillation of 1–2 L dialysate with gravity return of roughly 75% of the volume to ensure catheter function. Fascial and skin incisions were closed with absorbable suture, a titanium tip is placed on the exiting catheter, and the tubing set is secured to this tip. A total of 5000 units of heparin (in 20 cc of 0.9%NS) is used to flush the catheter as sterile dressings are applied for both techniques. While all patients prior to 2015 stayed overnight for catheter teaching, both techniques consistently offer out-patient status for all patients.

Data analysis

Non-normality of data distribution mandated comparisons between groups were performed with non-parametric tests (Mann–Whitney). All statistical tests were two-sided and a p-value of 0.05 was considered statistically significant. Continuous data is presented as means with standard deviation (SD) or median (range), and categorical data as counts and

percentages. All statistical analyses were performed using JMP (Java Memory Profiler) program (version 13.0, Cary, North Carolina, USA).

Results

Between 2005 and 2018, 173 patients underwent peritoneal dialysis catheter placement procedures by two staff surgeons at the Mayo Clinic-Rochester. A slight majority of patients were male (n = 90, 52%). Mean (SD) age was 59 years (1.9). Mean (SD) body mass index was 29.3 (6.4) kg/m². Mean (SD) ASA score was 3.1 (0.43). The mean operative time was 43.1 (2.1) minutes. 47% of the patients (n = 81) stayed overnight in the hospital – most commonly in the pre-2015 era for catheter teaching (n = 74, 91%). Six patients stayed for pain requiring intravenous analgesia medication (7%). One patient was admitted for hypotension requiring care in the intensive care unit. No intraoperative complications occurred.

The total postoperative complication rate for the index operation (n = 173) was 41% (n = 71). Of those with complications, catheter infections made up 42% (n = 30), catheter migrations 30% (n = 21), catheter malfunctions 28% (n = 20: fibrin deposition 11, omental/adhesional obstruction 8, and 1 leaked around the catheter). The median (range) post-operative day to complication occurrence was 309 (1–1918) days. Early (≤ 30 days) versus late (>30 days) complication rates for the index operation were 3% (5 patients) versus 38% (66 patients), respectively. The median (range) follow up was 346 (1–3497) days.

The re-operation rate for the index operation was 37% (n = 64) (See Table 1). The most common indications for reoperation were catheter infection (n = 24, 38%), catheter migration (n = 21, 33%), and catheter malfunction (n = 19, 30%). There were six catheter infections that did not require a reoperation as they were successfully treated with antibiotics (20% of total infections). Overall, catheter removal was the most common reoperation (n = 31, 48%), followed by catheter reposition (n = 22, 34%), and catheter replacement (n = 11, 18%). Of the first reoperation, 55% (n = 38) were male, mean (SD) age was 60 years (1.9), mean (SD) ASA was 3.2 (0.1), and the median (range) operative time was 37 minutes (6–108). Overnight stay following the second operation was 47% (n = 12), primarily due to catheter teaching (n = 10, 82%) and pain (n = 1, 9%). A hypoglycemic episode occurred in one patient requiring an overnight stay. A second re-operation for catheter replacement occurred in 17% (n = 29).

Of the 173 index operations, 22 were recently done (2016–17) laparoscopically by one surgeon, and 151 were done over the entire course of the study in an open fashion by the other surgeon (See Table 2). The gender, age, body mass index, and ASA were similar between both groups. Mean operative time for open was faster: 39 minutes vs. 69 minutes (p = < 0.001). Omentopexy (n = 4) or adhesiolysis (n = 3) occurred in 7 of 22 patients undergoing laparoscopic cases. Open and laparoscopic procedures had similar overall complication rates (40% vs. 36%), rates of infection (17% vs. 18%), and catheter malfunction (10% vs. 13%), respectively (p = NS). A higher rate of catheter migration (13% vs. 1%) was seen for the open approach for which the median follow up time was also longer (1167 vs. 348 days p = < 0.0001); range: open = 1–3497; laparoscopic 42–731).

Discussion

This retrospective study of our institutional effort to surgically insert and care for patients with CAPD catheters details several important findings: 1) both open and laparoscopic surgical approaches are technically safe procedures in patients with ESRD, 2) the open procedure is markedly faster, but there may be important benefits of a laparoscopic approach, 3) complications and reoperations are common in ESRD patients with CAPD catheters.

The intraoperative complication rate in our study suggests that a CAPD catheter can be safely placed in ESRD patients via open or

Table 1
Outcomes for Peritoneal Dialysis Index and Subsequent Operations.

Variables	Index operation	Reoperation				
		1st	2nd	3rd	4th	
N	173	64	29	12	2	
Gender male (%)	90 (51.7)	38 (59.3)	15 (50)	7 (53.8)	1 (33)	
Mean Age (years)	59.4	59.8	60.5	61.4	66.3	
Mean BMI*	29.2	29.7	29.7	29.2	27.7	
Mean ASA**	3.1	3.2	3.2	3.3	3.3	
Mean OT [§] (minutes)	43.1	40.5	44.7	76.2	34.5	
Overnight Stay (%)	81	31	12	3	1	
Reason for overnight stay (n)	Observation	76	30	11	3	1
	Pain	5	3	0	0	0
	Others	1	1	2	0	1
Complication (% of total operations)	71 (41)	23 (34.3)	13 (44.8)	2 (16.7)	1 (50)	
Complications (% of total operations)	Infection	30 (17.3)	7 (10.4)	5 (17.2)	0	0
	Migration	21 (12.1)	6 (8.9)	3 (10.3)	0	0
	Malfunction	19 (10.4)	10 (14.9)	5 (17.2)	2 (16.7)	1
	Other	1	0	0	0	0
Median time to complication (days)	308.9	267.4	178.1	337.6	343	
Indication for reoperation (% of reoperation)	Infection	24 (37.5)	12 (41.3)	4 (33.3)	0	
	Malposition	21 (32.8)	6 (20.6)	3 (25)	0	
	Malfunction	19 (29.6)	10 (34.4)	5 (41.6)	2 (100)	
Re-operation type (%)	Catheter reposition	22 (34.3)	6 (20.6)	2 (16.6)	0	
	Catheter replacement	11 (17.1)	13 (44.8)	3 (25)	1 (50)	
	Catheter removal	31 (48.4)	10 (34.4)	7 (58.3)	1 (50)	

* BMI – body mass index.

** ASA – American Society of Anesthesiologist.

§ OT – operative time.

laparoscopic placement. This is consistent with peritoneal dialysis literature that has identified intraoperative complications as rare for surgical placement, but slightly more common after guide wire-based percutaneous insertion of the catheter [26,27]. While this study and others supports the idea that the procedure itself is safe intraoperatively and harbors low rates of short-term complications, dozens of studies suggest that operating on patients with ESRD is fraught with complications: Schneider et al. found that overall complications (33 ESRD patients vs. 19 control patients), length of stay (8 vs. 3 days), and incidence of death (4% vs. 0% of patients) was increased in ESRD patients undergoing general surgery procedures [28]; patients with ESRD are all classified as ASA grade 3 or higher and Turet et al. established that the rate of postoperative surgical complications is closely linked to ASA score [29]. Importantly, Prause et al. studied 16,000 patients undergoing elective surgical procedures and found that 30 day mortality was 0.4% in ASA grade 1 or grade 2 patients, while mortality was 7.3% in ASA grade 4 patients [30].

The simplistic placement of CAPD catheters appears to be far better tolerated in ESRD patients (typically with ASA grades of 3) than more invasive and involved general surgical procedures.

Both methods to insert the CAPD catheter offer advantages: an open catheter placement is faster and requires less equipment, which translates to lower operative expenses and may decrease anesthesia risks [2]. Laparoscopic insertion allows for direct visualization, adhesiolysis, tethering or resecting omentum away from the catheter tip, evasion of bowel injury and a more accurate catheter placement. While our study is too small and the follow-up too short to comment on the superiority of open vs. laparoscopic techniques, other studies suggest that they are equivalent procedures [2,25]. Xie et al. and Wright et al. suggest that the selection of the procedure should be left up to the individual surgeon to decide based on each individual patient's body habitus, previous operations, and the surgeon's own skill set [2,25]. We would concur with this insight.

Table 2
Outcomes Comparing Laparoscopic vs. Open Index Operations.

	Laparoscopic	Open	P value	
N (%)	22 (12.7)	151 (87.3)		
Male (n, %)	12 (55)	78 (52)	0.7	
Mean Age (years)	57.5	59	0.6	
Mean BMI*	29.8	29.2	0.6	
Mean ASA**	3.1	3.1	0.4	
Mean OT [§] (minutes, std. dev)	68.6 (30)	39.4 (25)	<.0001	
Overnight Stay (n, (%))	8 (36)	73 (48)	0.3	
	8 (100)	64 (92)	0.3	
	0	5 (7)	0.2	
Indication for an overnight stay (n, %)	0	1 (1)	0.6	
	8 (36.3)	61 (40.3)	0.6	
	4 (18.1)	26 (17.2)	0.1	
Complications (% complication, total operations)	Malposition/Migration	20 (13.2)	0.2	
	Malfunction	3 (13.6)	15 (9.9)	0.06
	3 (13.6)	1167.84	<0.0001	
Follow up (days)	348.41	41		
Mortality <30 days	1	0		
Mortality >30 days	3	41		

* BMI – body mass index.

** ASA – American Society of Anesthesiologists.

§ OT – operative time.

The cumulatively high complication rate in this study (41%) was not unexpected. Studies report varying PD catheter placement complication rates, as low as 10% and as high as 70% [4,10,11,13,15–17,20–25]. These studies report the complication incidence separately by type of complication, and not with a cumulative complication rate. Hagen et al. performed a comprehensive meta-analysis, looking at the complication rates utilizing results of up to 9 studies for open and laparoscopic cases [4]. Combining the open and lap outcomes together, the overall rates were: catheter migration in 10% (31/319), leakage in 6% (48/826), catheter obstruction in 7% (48/665), peritonitis in 21% (117/541), and exit-site/tunnel infection in 15% (71/474) [4,11,13,15–17,20–25]. Pooling these percentages together, collectively a complication was found in 59% of the total patient pool.

The patients undergoing CAPD catheter placement are complex. Many patients have undergone multiple prior operations for various illnesses, injuries, and kidney transplants. Previous adhesions and altered anatomy may make it difficult to keep the catheter free from adhesions and obstruction. The literature offers conflicting data: Chen et al. found that previous abdominal surgery has little effect on surgical complications (17% catheter malfunction and 33% peritonitis with prior abdominal surgery versus 13%, and 29%, respectively – without prior surgery) [31]. Tiong et al. found that prior abdominal surgery did have an impact on early complication rates (42% with prior abdominal surgery, 26% without), but not on late complication rates [32]. Both studies had small numbers of study patients (Chen = 122 patients, Tiong = 139) [31].

Fibrin buildup and catheter calcification are issues that led to many of the catheter malfunctions in CAPD patients. Hamada et al. reported that exposure to a long-term incompatible PD solution creates morphological and functional peritoneal changes that become problematic with catheter function (fibrin deposition, peritoneal turbidity, and calcification). Using a neutral PD solution may be a potential solution, as it is more biocompatible in preventing morphological changes compared to an acidic solution [33,34]. Hamada also made a score system to evaluate the relationship between morphological and clinical findings. The score of macroscopic changes increased with PD duration although he was unable to evaluate the severity of each finding. Furthermore, a systemic review by Cho et al. reported that neutral pH, low glucose breakdown product solutions such as icodextrin improved peritoneal ultrafiltration and led to higher residual renal function after use of over 12 months without added risks of harm [35].

There are multiple limitations to our study. The study was conducted retrospectively from a single institutional experience. The data was generated from two separate surgeons: one with 20+ years using an open technique and the other with only a 2 year experience using a laparoscopic approach. Therefore, the number of patients varied greatly between open and laparoscopic groups and the follow-up was markedly different; statistical analysis may include both type 1 and type 2 errors. While ESRD patients were not blinded to the operative technique, they were randomly assigned to one of two surgeons: both surgeons utilized the same intra-operative catheter testing with dialysate and heparin flushing and importantly, the post-operative care protocol and care teams were the same (nephrology nurses, avoid usage of catheter for 4 weeks, etc.).

We plan to develop and change our protocol for the catheter placement procedure. There are many surgical adjustments that have been tried by others with varying success: tacking the omentum in order to prevent potential catheter obstruction, fixing the catheter in order to prevent migration, or irrigating the abdomen more frequently in the hopes of preventing infection. Prospective studies examining how these protocol changes affect the complication and reoperation rates for these patients are needed.

Conclusion

While the placement of CAPD catheters in patients with end stage renal disease is technically safe via open or laparoscopic approaches,

the follow-up care of these fragile patients is humbling. Our study confirms that roughly 40% of all CAPD patients will require reoperation for either infection or malfunction of the catheter. Further refinements in operative technique coupled with more rigorous and insightful catheter care may lead to better long term outcomes in this group of complex patients.

Author contribution

Study design, data collection, statistical analysis, manuscript preparation, editing after reviews.

Declaration of Competing Interest

None.

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