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Original Article

Urgent-Start Peritoneal Dialysis Catheter Placement: Comparative Study between Percutaneous Image-Guided versus Laparoscopic Techniques

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Abstract

Objective: The objective of this study was to compare the outcomes and complications of percutaneous image-guided versus laparoscopic peritoneal dialysis (PD) catheter placement techniques in the urgent-start setting. **Materials and Methods:** The medical records of 273 patients who had their first PD catheter between November 2012 and May 2017 were retrospectively reviewed. Patients were divided into radiologic group (n = 26) and laparoscopic group (n = 16). Descriptive and Kaplan–Meier (KM) analysis were used to compare time to first complication, time to catheter removal, and patient survival between the two groups. Complication-free and catheter removal rates at 1, 3, and 12 months were estimated from KM analysis. **Results:** A total of 42 patients were included in the study. The baseline demographics were similar between the two groups. In the radiologic group, the estimated 1, 3, and 12 months' complication-free rate were 100%, 94%, and 67%, respectively, which was not significantly different from 93%, 85%, and 45%, respectively, in the laparoscopic group (P = 0.543). The rate of catheter complications was not significantly different between the radiologic group (50%) and the laparoscopic group (31%) (P = 0.3382). The catheter removal rate in the radiologic group was 8, 18%, and 38% at 1, 3, and 12 months, respectively, versus 0%, 8%, and 20%, respectively, in the laparoscopic group (P = 0.298). The overall patient survival between two groups was not significantly different (P = 0.116) with estimated patient mortality of 15.4% at 12 months in the radiologic group and no deaths in the laparoscopic group. **Conclusion:** Image-guided percutaneously placed PD catheters have a similar complication and removal rates compared to laparoscopically placed catheters in the urgent-start setting.

Keywords: *Chronic kidney disease, end-stage renal disease, fluoroscopic, laparoscopic, peritoneal dialysis, urgent-start*

Introduction

In the United States, the prevalence of chronic kidney disease (CKD) and end-stage renal disease (ESRD) is 13.6% and 0.1%, respectively.[1] Approximately 80% of patients initiate hemodialysis (HD) using a central venous catheter (CVC) in the urgent-start setting (i.e., no preestablished HD or peritoneal dialysis [PD] access).[2] However, HD using a CVC is associated with significantly increased risk of infections, thrombosis, and cardiovascular morbidity, as well as increased mortality, particularly in the first 90 days, compared to arteriovenous fistulas, grafts, or PD.[3-7] On the other hand, PD is a cost-effective and patient-centered modality compared to HD[8] with many advantages regarding lifestyle flexibility, preservation of kidney function,[9] and improved mortality.[10] Nevertheless, PD in the urgent-start setting is frequently underutilized.[11]

In elective situations, PD catheters are usually used at least 21 days after their placement to allow healing and to prevent complications. Over the past decade, urgent-start PD, which allows for dialysis within hours after PD catheter insertion, has gained considerable interest among nephrologists seeking an alternative to CVC use in HD.[11] While PD catheters are better regarding overall morbidity and mortality, they are not entirely without risk.[12]

The objective of this study is to compare surgical PD catheter placement with image-guided (fluoroscopy and ultrasound) PD catheter placement in the urgent-start setting to assess for differences in technical outcomes, clinical outcomes, and complications. A recent study suggested PD catheter outcomes in prospective

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randomized trials may vary due to exclusion of obese patients and those who had prior surgery, resulting in outcomes that represent what can be achieved under the most favorable circumstances.[13] Therefore, our study was designed to include obese patients and patients with prior surgery for comparison. The patients, who underwent simultaneous adhesiolysis, omentopexy, or hernia repairs, were included in the study. Since the exclusion of these patients might have adversely affected the results in favor of the radiologic technique.

Materials and Methods

Study population

This retrospective study was approved by our Institutional Review Board and informed consent was obtained. Two hundred and seventy-three patients underwent PD catheter placement between November 2012 and May 2017. The patients were divided into two groups; the radiologic group (n = 66) which included patients who had PD catheters placed by the fluoroscopy and ultrasound-guided technique by interventional radiologists or interventional nephrologists under conscious sedation and the laparoscopic group (n = 207) which included patients who received PD catheter insertion by the laparoscopic technique by surgeons under general anesthesia. In our institution, patients with comorbidities that make them high-risk patients for receiving general anesthesia are usually referred for radiologic PD catheter placement, while the rest are usually referred for laparoscopic catheter placement. Patients with CKD Stage 5 or ESRD who were 19 years or older and had their first PD catheter placed during the study period were included in the study. Patients who had PD catheter placed but not used during the study period because they did not meet the criteria for dialysis (embedded catheters) and patients who had their catheters successfully placed after more than one attempt were excluded from the study. Patients who required adhesiolysis, omentopexy, or hernia repair during laparoscopic placement and patients with prior abdominal surgery or severe obesity, defined as body mass index of ≥35, were included in both groups. Figure 1 shows the algorithm for patients' inclusion and exclusion. A total of 42 patients required urgent-start PD, with 26 of these patients in the radiologic group and the remaining 16 patients in the laparoscopic group. Patients' demographics were obtained from the medical records were recorded.

Study outcomes

Following PD catheter placement, the patients were followed up regularly by their nephrologists. Information on catheter complication and removal was obtained from nephrology clinic notes in the patients' medical records.

Complication rates related to PD catheter placement after 1, 3, and 12 months were estimated in each group. This composite endpoint included mechanical, technical, and infectious complications. Inadequate catheter drainage, catheter leak through the exit site, catheter malfunction, and abdominal herniation were all considered to be mechanical complications. Primary catheter leak was defined as a leak that occurs from the exit site within 48 h of catheter insertion and before the start of PD. Catheter leak was defined as leak that occurs from the exit site when the catheter was used for PD. Bowel perforation, intraperitoneal bleeding, muscle hematoma, and inability to insert or use the catheter were considered technical complications. Infectious complications included exit-site infection, tunnel infection, and catheter-related peritonitis which was defined as an infection that begins at the exit site of the peritoneal catheter, migrates along the subcutaneous pathway of the catheter, and leads to peritonitis.

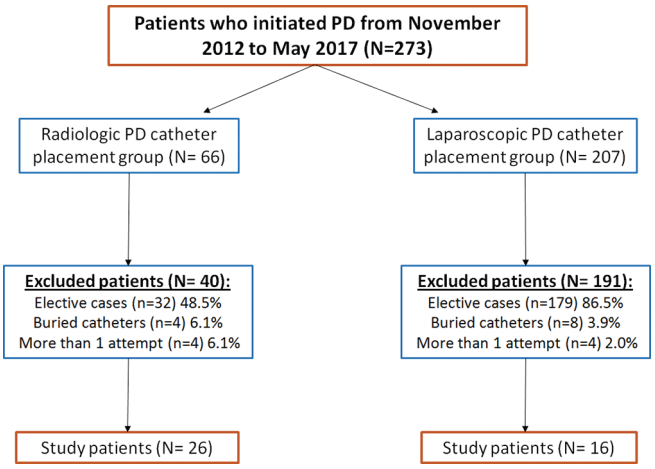

Figure 1: Algorithm for patients' inclusion and exclusion

Catheter removal rates at 1, 3, and 12 months and patient mortality were estimated. The average days-to-first complication, average days-to-catheter removal, and mortality rate were also calculated. Data on complications were obtained from a dialysis access database and from the patients' electronic medical record.

Technique of radiologic and laparoscopic catheter placement

Percutaneous PD catheter was placed using fluoroscopy and ultrasound guidance as has been previously described in the literature.[14-16] Percutaneous placement was performed by three interventional radiologists and one interventional nephrologist each with at least 5 years of experience. Swan-neck double-cuff curled catheters were used (Medtronic, USA). Laparoscopic catheter insertion was performed by one surgeon with at least 5 years of experience in placing PD catheters using this technique. The laparoscopic technique has similarly been described in the literature.[17] One gram of cefazolin (Pfizer, USA) was administered within 1 h before the procedure in both groups. Dialysis was started urgently within 48 h of catheter insertion with low-volume dialysis until wound healing, which usually occurs after 3 weeks.

Statistical analysis

Descriptive analysis was presented for patient demographics, clinical history, imaging, and laboratory data, including mean and standard deviation and count and percentage. To compare continuous variables between the two groups, two sample *t*-tests were conducted. Careful attention was given to the normality assumption, which was examined by normal probability plots and histograms. To compare categorical variables, Fisher's exact test was conducted. Time to complication and time to catheter removal were analyzed using the Kaplan–Meier (KM) method. The 1, 3, and 12 months' complication-free and catheter removal rates were estimated from KM curves. Time to complication and time to catheter removal were calculated from the date of procedure to the date of complication and the date of catheter removed within 12 months. The right sensor was considered if patients lost at the end of the study or if the event did not occur within the study duration. For all inferences, the statistically significant level was set to $P \leq 0.05$. All analyses were conducted using SAS v. 9.4 (SAS institute Inc., Cary, NC, USA).

Results

The average follow-up period was 738.9 (standard deviation [SD] = 436) days. Patients in both groups had similar demographics and medical comorbidities [Table 1], although patients in the radiologic group tend to be older.

A list of catheter-related complications for the radiologic and laparoscopic groups is shown in Table 2. The overall catheter complication rates were not different between the radiologic and laparoscopic groups (50% vs. 31%, P = 0.3382). Peritonitis was one of the most frequently encountered complications and occurred in six patients (23%) in the radiologic group versus four patients (25%) in the laparoscopic group. Peritonitis occurred at a mean of 75.5 days (SD = 97.8) and 129 days (SD = 183.3) in the radiologic and laparoscopic groups, respectively, (P = 0.0224). There was one case of exit-site/tunnel infection that was diagnosed clinically and the proper antibiotics were administered until the resolution of infection.

Catheter malfunction and leak tended to occur more frequently in the radiologic group (27% and 15%, respectively) compared to the laparoscopic group (6% and 0%, respectively).

KM analysis showed no significant difference in the time to first complication between both groups (P = 0.543) [Figure 2]. The estimated 1, 3, and 12 months complication-free rate was similar between the two groups (100% vs. 93.1%, 93.75% vs. 85.01%, and 66.96% vs. 45%), in the radiologic and laparoscopic groups, respectively [Table 3]. The average days to first complication was 66.9 days (SD = 101.4 days, median = 6 days, and range 1–300 days) in radiologic group and 57.8 days (SD = 45.1 days, median = 50 days, and range 16–115 days) in laparoscopic group.

KM analysis showed no significant difference in the time to catheter removal between both groups (P = 0.298) [Figure 3]. The estimated catheter removal at 1, 3, and 12 months was similar between both groups being 8.16%,

Table 1: Demographics and baseline characteristics of the urgent-start radiologic and laparoscopic groups

Characteristics	Radiologic group (n=26), n (%)	Laparoscopic group (n=16), n (%)	P
Age*	50.7 (16.7)	41.4 (12.4)	0.078
Sex			
Male	16 (62.5)	6 (37.5)	0.129
Female	10 (38.5)	10 (62.5)	
BMI*	28.2 (6.4)	27.1 (6.8)	0.698
Morbid obese (BMI >35)	7 (27)	1 (6.25)	0.101
Diabetes	13 (50.0)	9 (56.3)	0.694
Hypertension	24 (92.3)	16 (100)	0.257
Coronary artery disease	5 (19.2)	1 (6.3)	0.243
Congestive heart failure	7 (26.9)	2 (12.5)	0.269
Peripheral vascular disease	3 (11.5)	1 (6.3)	0.571
Cerebrovascular disease	3 (11.5)	2 (12.5)	0.926

*Mean (SD). BMI: Body mass index, SD: Standard deviation

Table 2: A list of catheter complication for radiologic and laparoscopic groups

	Radiologic (n=26), n (%)	Laparoscopic (n=16), n (%)	P
Total complications	13 (50)	5 (31.3)	0.3382
Exit-site/tunnel infections	0	1 (6.3)	
Peritonitis	6 (23.1)	4 (25.0)	
Catheter malfunction	7 (26.9)	1 (6.3)	
Catheter leak	4 (15.4)	0	
Primary leak	1 (3.9)	0	
Hernia	2 (7.7)	1 (6.3)	

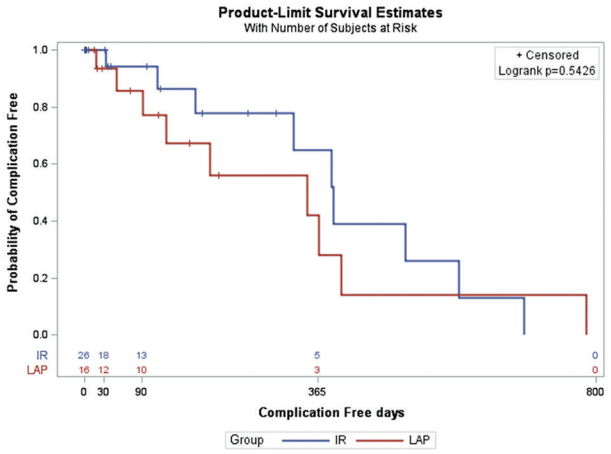

Figure 2: Kaplan–Meier curves for complication-free catheter survival at 12 months in the radiologic and laparoscopic groups

Table 3: Estimated catheter complication-free rates from the Kaplan-Meier curves for the radiologic and laparoscopic groups

	Radiologic (*n*=26)	Laparoscopic (*n*=16)	*P**
Estimated 1-month complication-free rate (%)	100	93.1	0.543
Estimated 3-month complication-free rate (%)	93.75	85.01	
Estimated 12-month complication-free rate (%)	66.96	45	

*Log-rank test

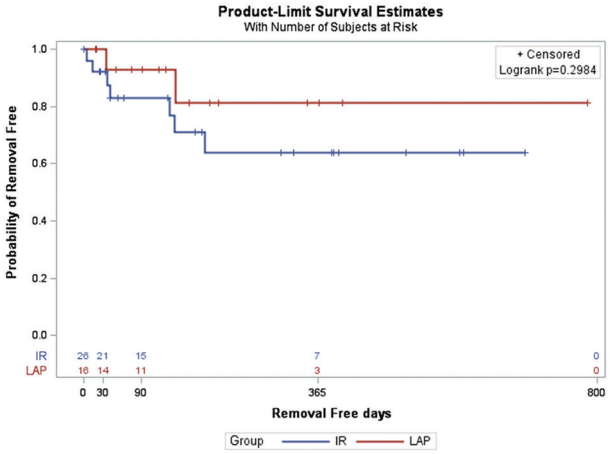

Figure 3: Kaplan–Meier curves for overall catheter removal at 12 months in the radiologic and laparoscopic groups

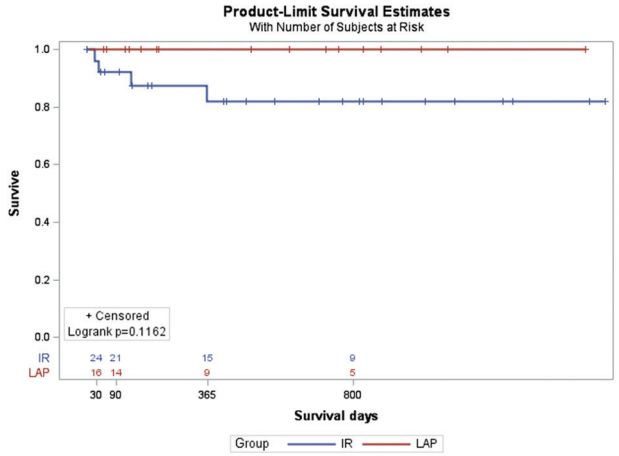

Figure 4: Kaplan–Meier curves for overall survival of patients at 12 months in the radiologic and laparoscopic groups

17.83%, and 37.55%, respectively, in the radiologic group, compared to 0%, 7.69%, and 20% in the laparoscopic group, respectively (P = 0.298) [Table 4]. The average catheter removal days was 80.3 days (SD = 72.8 days, median = 42 days, and range 5–189 days) in radiologic group and 89.0 days (SD = 76.4 days, median = 89.0 days, and range 35–143 days) in laparoscopic group. The laparoscopic group had no deaths at 3 and 12 months compared to 7.7% and 15.4%, respectively, in the radiologic group. KM survival analysis showed no significant difference in the overall survival of patients between both groups (log-rank P = 0.116) [Figure 4]. Causes of death in the four patients in the radiologic group were not related to the procedure or catheter complications and were due to septic shock from pneumonia in one patient, multiorgan failure in one patient, and cardiopulmonary arrest in two patients.

Discussion

In a nonurgent setting, the patients typically defer PD initiation over 2 weeks to allow for tissue ingrowth of the deeper Dacron cuff and to minimize the risk of dialysate leak into the subcutaneous tissue. However, the patients presenting with advanced disease frequently find themselves faced with the choice of either a temporary CVC with the associated morbidities or the risk of dialysate leak by the earlier use of the PD catheter.[18]

Several reports have described specific maneuvers to attempt to minimize the risk of dialysate leak associated with PD catheter in urgent-start setting, such as recumbent dialysis only with lower dwell volumes and avoidance of dialysate dwells while the patient is upright.[18-20] Urgent-start PD programs have been developed across the country in an attempt to provide a more expeditious entry point for late-presenting patients interested in home dialysis with PD. These so-called "Urgent-Start PD" programs have shown that more rapid initiation of PD is a viable option that can avoid exposing patients to the risk of temporary CVC and the need for subsequent vascular procedures to establish permanent access.[18]

PD catheter placement within 24–48 h of presentation is an integral part of urgent-start programs. This mandate is difficult to fulfill by surgical services in most busy academic institutions and private practices due to challenges in patient access to these services in a timely manner.[14-18] Therefore, many centers have developed pathways for imaging-guided percutaneous placement of PD catheters by interventional radiologists, followed by assisted PD treatments performed by trained PD nurses in the outpatient setting until the patient is able to be trained in self-care at home. This approach was recently found to be significantly more cost-effective in comparison with CVC placement and HD initiation, with the cost savings at 90 days deemed to be almost entirely due to the establishment of permanent PD catheter access versus having a CVC placed then requiring subsequent procedures to establish permanent vascular access.[19] Furthermore, this approach has permitted rapid growth in many PD programs

Table 4: Estimated catheter removal rates from the Kaplan-Meier curve for radiologic and laparoscopic groups

	Radiologic (*n*=26)	Laparoscopic (*n*=16)	*P**
Estimated 1-month catheter removal rate (%)	8.16	0	0.298
Estimated 3-month catheter removal rate (%)	17.83	7.69	
Estimated 12-month catheter removal rate (%)	37.55	20	

*Log-rank test

in the United States, and the 90-day clinical outcomes have been acceptable in these established centers.[20] Urgent-start PD programs have now routinely incorporated both surgical and percutaneous catheter pathways in an attempt to avoid temporary CVCs and to provide more patient-centered care at a lower cost.[21,22]

Several prior studies have addressed the complications, safety, mortality, technique, and survival of PD catheter placement outside of the urgent-start setting. Five studies focusing on PD catheter placement using the radiologic technique for urgent-start PD demonstrated a complication rate ranging from 9.6% to 47.6%,[18,23-26] whereas four studies evaluated complications of laparoscopic PD catheter placement revealed a total complication rate ranging from 9% to 42.4%.[21,26-28] In these studies, the patients were followed up from 1 to 6 months only after catheter insertion. The current study is, therefore, consistent with the published data based on our demonstrated complication rate of 50% and 31% for the radiologic and laparoscopic techniques, respectively, even though the patients in the current study had a longer follow-up (mean = 24.6 months). Catheter leak was one of the most commonly encountered complications, ranging between 1.9% and 33.3%[18,23-26] in the radiologic group and 0%–20% in the laparoscopic group.[21,26-28] Our study shows a similar risk of leak in regard to published data with a rate of 15% for radiologic and 0% for the laparoscopic group. Eight identified studies related to PD catheter infections, including peritonitis and exit-site infections in the urgent-start setting, showed a rate of 2.4%–15.4% for peritonitis and 1.3%–11% for exit-site infections. The infection rates were slightly lower in the laparoscopic technique compared to the radiologic technique with a rate of 0%–19.1%[21,26-28] versus 2.4%–33.3%,[18,23-26] respectively. In the current study, the infection rate of 31% for laparoscopic technique and 23% for the radiologic technique is slightly higher than the currently published data. This high rate of catheter-related infections in this study could be explained by our longer follow-up period (mean of 24 months) compared with a mean follow-up period of 1–6 months in other published reports. Out of the aforementioned eight studies, three studies showed no significant difference between urgent-start and elective PD catheter placement regarding catheter leak and infection rates.[18,27,28]

Catheter dysfunction is another complication of PD catheter placement encountered in an urgent-start setting, with rates ranging from 2.4% to 22.2%[18,23-26] for the radiologic technique and 2.4%–15.4%[21,26-28] for the laparoscopic technique. The current study demonstrates a somewhat lower rate of catheter dysfunction using the laparoscopic technique compared to the radiologic technique, which might be attributed to the advanced laparoscopic techniques performed during laparoscopic PD catheter placement such as adhesiolysis and omentopexy. A recent prospective study of 35 patients who initiated urgent-start PD after having a catheter placed percutaneously had a 20% mortality rate at 3 months.[29] In the current study, the 3-month mortality rate was 7.7% and 0% for the radiologic and laparoscopic groups, respectively. However, this difference between the two catheter insertion techniques was not statistically significant.

The limitations of this study include its retrospective nature leading to an inherent selection bias. However, the existence of a dialysis access registry at our center provides a reasonable degree of confidence that the information on the catheter placement, removal, and complications was accurate and complete. The small sample size is another limitation, as is the fact that this is a single-center experience and the results may not be generalizable.

Conclusion

This study adds to the emerging literature suggesting that PD catheter placed using image-guided percutaneous technique can achieve comparable outcomes to laparoscopically placed catheters and therefore can offer a minimally invasive catheter placement option for patients in need of urgent dialysis. Further multicenter studies with larger sample sizes are needed.

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Nil.

Conflicts of interest

Ahmed Kamel Abdel Aal: Consultant, Abbott Medical, Bard Peripheral Vascular, Baxter Healthcare, Boston Scientific, W. L. Gore, Sirtex Medical, Surefire Medical.

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