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Clinical Characteristics and Outcomes of Ultrasound-Guided Percutaneous Peritoneal Dialysis Catheter Insertion: An ISN Interventional Nephrology Training Center Experience

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Abstract

Background: A functioning dialysis catheter is vital in initiating patients in peritoneal dialysis. The catheter can be inserted through the following techniques: Open surgery, laparoscopy, peritoneoscopy, or percutaneous. The advantages of percutaneous technique are the following: Less delay in initiation of renal replacement therapy, can performed at bedside or in a day-surgery room, can be done with local anesthesia alone, lower cost and shorter hospital stay. The objective of this study is to demonstrate the clinical characteristics and outcomes of ultrasound-guided peritoneal dialysis catheter insertion at the National Institute of Cardiology, Mexico City, Mexico and an International Society of Nephrology (ISN) Training Hospital for Interventional Nephrology.

Methods: The medical records of patients who underwent the ultrasound-guided percutaneous peritoneal dialysis catheter insertion from July 2019 to September 2022 were retrospectively reviewed. A total of 36 patients were analyzed. The different clinical characteristics such as age, gender, diagnosis, BMI, blood pressure and laboratory results were recorded. The outcomes: Successful catheter insertions, location of puncture, duration of procedure and early complications (<30 days) were also recorded and analyzed.

Results: The mean age was 51.58 ± 17.2 years with equal distribution of males and females. More than half of patients (55.6%) had a previous abdominal surgery, with appendectomy as the most common (13.9%). Their diagnoses were generally classified into two–chronic kidney disease stage 5 (55.6%) and cardiorenal syndrome (44.4%). The main indication for the procedure was initiation of renal replacement therapy (88.9%). The mean BMI was 23.09 ± 0.763 kg/m^2. The majority of patients had anemia with mean hemoglobin of 8.43 ± 0.51 g/L, but the bleeding parameters were within normal: Platelets 204.05 ± 14.88 × 109/L, INR 1.09 (1.03–1.18) and PTT 31.70 (28.3–34.70) seconds. The mean BUN was 48.59 ± 4.3 mg/dl and mean creatinine was 5.88 ± 0.65 mg/dl.

Successful percutaneous insertion of the peritoneal dialysis catheter occurred in 77.8% (28/36). The majority of the procedures were done using a left paramedian approach (92.9%) as the entry or puncture site. Punctures were successful on the first attempt (89.3%). The average duration of the procedure was 84.82 ± 31 minutes. A high percentage (89.3 %) of patients did not develop any early complication. One patient had an exit site leak (3.6%) and two patients suffered visceral injuries [intestinal puncture (3.6%) and uterine injury (3.6%)]. Only age was noted to be significantly different from the patients with complications, as compared to the patients without complications. Patients with complications were older with a mean age of 68 ± 3.60 years old.

Conclusion: An ultrasound-guided percutaneous placement of peritoneal dialysis catheter can be performed safely and offers a clinically effective alternative to surgical technique. The majority of the outcomes are similar or better compared to what has been reported in the literature.

Keywords: End-stage renal disease; Peritoneal dialysis; Peritoneal dialysis catheter; Ultrasound

Introduction

A functioning peritoneal dialysis catheter is vital in initiating patients in peritoneal dialysis. Having a safe and reliable method of accessing the peritoneum may affect patients outcomes with respect to infectious and mechanical complications and downstream technique failure [1]. The catheter can be inserted through the following techniques: Open surgery, laparoscopy, peritoneoscopy, or percutaneous. The open surgical approach, performed by surgeons, is still the most common technique worldwide. However, it is limited by the requirements of an operating room and the use of general anesthesia which may not be tolerated by critically-ill patients. The percutaneous

technique, on the other hand, can be performed by an interventional nephrologist or interventional radiologist. This could be performed either through a blind or an image-guided technique (ultrasound with or without fluoroscopy). The advantages of percutaneous technique are the following: Less delay in initiation of renal replacement therapy, can be performed at bedside or in a day-surgery room, can be done with local anesthesia alone (favorable for critically-ill patients), lower cost and a shorter hospital stay.

It is often argued that no single implantation approach has been shown to produce superior outcomes. Operator performance aside, when catheter placement by percutaneous needle-guidewire with or without image guidance, open surgical dissection, peritoneoscopy and laparoscopy are compared side to side on identical study populations, the outcomes reported in the literature are similar [2]. In fact, a surgical approach may have more catheter mechanical dysfunction as compared to the ultrasound-guided percutaneous approach [1]. This is being questioned by some clinicians because of a possible selection bias, as most patients who were selected for the percutaneous approached may have a lower BMI and an unbreached abdomen. However, two studies demonstrated that the outcomes of an open-surgical approach and a percutaneous approach are the same regardless of the BMI and history of abdominal surgery [3,4].

In doing the percutaneous peritoneal dialysis catheter insertion, ISPD recommends the use of ultrasound guidance (with or without fluoroscopy) to improve outcomes and to lessen complications [2]. However, most studies do not compare the outcomes between the blind approach and the ultrasound-guided approach.

The objective of this study was to demonstrate the clinical characteristics and outcomes of ultrasound-guided peritoneal dialysis catheter insertion at the National Institute of Cardiology, Mexico City, Mexico and an International Society of Nephrology (ISN) Training Hospital for Interventional Nephrology.

Materials and Methods

Study population

This is a single-center study with patients coming from the National Institute of Cardiology “Ignacio Chavez”, Mexico City, Mexico. This is one of the twelve (12) affiliated training hospital of International Society of Nephrology (ISN) for Interventional Nephrology fellowship training. Among the twelve hospitals, this is only one of the three hospitals that include peritoneal dialysis catheter insertion in their curriculum.

The medical records of patients who underwent the ultrasound-guided percutaneous peritoneal dialysis catheter insertion from July 2019 to September 2022 were retrospectively reviewed. Inclusion criteria included all patients who were 18 years old and above, underwent the procedure regardless of the indication (initiation of peritoneal dialysis or removal of intractable ascites). Patients, who had an initial puncture for contemplated percutaneous catheter insertions, even if they were eventually converted to open, were also included.

Exclusion criteria were patients who had no follow up records after the procedure and those who had their catheters removed in less than a month (e.g. resolution of AKI). A total of 36 patients were analyzed. The different clinical characteristics such as age, gender, diagnosis, BMI, blood pressure and laboratory results were recorded. The outcomes: Successful catheter insertions, location of puncture, duration of procedure and early complications (<30 days) were also recorded and analyzed. The long-term complications (>30 days to 1 year) were no longer analyzed because of lack of data in all subjects.

Technique of ultrasound-guided percutaneous peritoneal dialysis catheter insertion

The procedures were done by ISN interventional nephrology fellows, nephrology residents and an interventional nephrologist. All procedures done by the trainees were supervised by an interventional nephrologist.

Once informed consent was obtained, patients were referred to anesthesia service for conscious sedation (Propofol, Midazolam and Fentanyl). Cefazolin 1 gram was given as a prophylactic antibiotic. Pre-operative ultrasonography of the abdominal wall was performed to plan the possible insertion site. The epigastric arteries were visualized so that it would be avoided during the puncture. The catheter that we used was a coiled-tip, double-cuff catheter (Argyle Peritoneal Dialysis Catheter, 57 cm). The upper border of the coiled tip was aligned with the upper border of the symphysis pubis, to locate the ideal location of the deep cuff or insertion site. A paramedian approach (~3 cm lateral to the umbilicus) was used as a landmark for insertion. Together with marked location of the epigastric vessels, distance from the upper border of the coiled-tip and a paramedian approach, the position of the insertion site was selected and marked. The entry site was infiltrated with 1% lidocaine, then a small incision (<1 cm) was done through the skin. This was followed by a blunt dissection until the anterior aponeurosis is reached and palpated. An 18-gauge introducer needle was inserted at an angle of 45 degrees, guided by a linear probe (6-13 MHz) ultrasound, using an in-plane needle and ultrasound axis approach. The tip of the needle should be visualized to puncture the parietal peritoneum, avoiding the bowel loops. The ultrasound mode was then shifted to color doppler and a 10 cc of saline was forcefully injected. A color flow should be visualized in the peritoneum which indicates that the tip was inside the peritoneal cavity. The needle was then attached to an intravenous fluid (0.9% saline) through a macroset infusion set. A good flow adds conviction that the tip of the needle was inside the peritoneal space. The peritoneal space was filled 500 ml to 1000 ml of fluid to further increase the space between the bowel loops and parietal peritoneum. A 0.965 mm guidewire was then inserted through the introducer needle. Series of dilators and peel-apart sheath was then inserted. The catheter was inserted in the peritoneum through a pull-apart sheath using a metal guide. The tip was directed to the pelvic cavity. Ultrasound was also used to confirm the correct placement of the metal guide and catheter. The patency of the catheter was checked by infusing 0.9% saline through the

catheter. An exit-site was planned and a tunnel was created. The superficial cuff should be more than 2 cm to 4 cm from the exit site. The patency of the catheter was rechecked again. The skin entry site was sutured using nylon, cutting 4-0. The titanium connector and transfer set were connected.

At the ward, all catheters were used immediately using a low fill volume. The inflow and outflow were observed and possible early complications were monitored.

Study design

This is a retrospective cross-sectional study. The normal distribution of the variables was assessed using the Kolmogorov-Smirnov test. Quantitative variables were described by means and Standard Deviation (SD) or medians and Interquartile Ranges (IQR), according to their distribution. Categorical variables were described by frequencies and proportions. For the comparative analysis, the *Chi-square* test was used for qualitative variables and the T-student or Mann-Witney U test for quantitative variables depending on their distribution. Odds Ratio (OR) and 95% of Confidence Intervals were used (CI). A P-value of <0.05 was considered statistically significant. The SPSS version 25 data package for Macintosh was used.

Results

The demographics and clinical characteristics of the 36 patients are listed in **Table 1**. The mean age was 51.58 ± 17.2 year with equal distribution of males and females. More than half of patients (55.6%) had a previous abdominal surgery, with appendectomy as the most common (13.9%). Their diagnoses were generally classified into two–chronic kidney disease stage 5 (55.6%) and cardiorenal syndrome (44.4%). The main indication for the procedure was initiation of renal replacement therapy (88.9%), but removal of an intractable ascites was also a significant indication (11.1%). The mean BMI was 23.09 ± 0.763 kg/m^2. For the baseline laboratories, majority of patients had anemia with mean hemoglobin of 8.43 ± 0.51 g/L, but the bleeding parameters were within normal limits: Platelets 204.05 ± 14.88 × 109/L, INR 1.09 (1.03-1.18) and PTT 31.70 (28.3-34.70) seconds. The mean BUN was 48.59 ± 4.3 mg/dl and mean creatinine was 5.88 ± 0.65 mg/dl.

Table 1: Demographics and baseline characteristics.

Characteristic	Results (n = 36)	Percentage (%)
Age (years)	51.58 ± 17.2	
Sex		
Male	18	50%
Female	18	50%
Previous abdominal surgery	20	55.60%
Appendectomy	5	13.90%
Cholecystectomy	4	11.10%
Caesarian section	3	8.30%
Explore laparotomy	2	5.60%
Hysterectomy	2	5.60%
Tenckhoff catheter insertion	1	2.80%
Others	1	2.80%
Diagnosis		
Chronic kidney disease stage 5	20	55.60%
Undetermined cause	10	27.80%
Chronic glomerulonephritis	4	11.10%
Diabetic kidney disease	4	11.10%

Renal allograft rejection	2	5.60%
Cardiorenal syndrome	16	44.40%
Indication		
Initiation of renal replacement therapy	32	88.90%
Removal of intractable ascites	4	11.10%
Height (m)	1.65 (1.57-1.68)	
Weight (kg)	61.37 ± 9.82	
BMI (kg/m^2)	23.09 ± 0.763	
Blood pressure (mmHg)–Pre-procedure		
Systolic blood pressure	126.53 ± 16.52	
Diastolic blood pressure	73.95 ± 8.77	
Blood Pressure (mmHg)–Post-procedure		
Systolic blood pressure	127.00 ± 21.56	
Diastolic blood pressure	75.16 ± 11.75	
Hemoglobin (g/L)	8.43 ± 0.51	
WBC (× 109/L)	6.31 (5.31-7.55)	
Platelets (× 109/L)	204.05 ± 14.88	
INR	1.09 (1.03-1.18)	
PTT (seconds)	31.70 (28.3-34.70)	
BUN (mg/dl)	48.59 ± 4.3	
Creatinine (mg/dl)	5.88 ± 0.65	

The outcomes and complications are summarized in **Table 2**. Successful percutaneous insertion of the peritoneal dialysis catheter was noted to be at 77.8%. Majority of the procedures were done using a left paramedian approach (92.9%) as the entry or puncture site. Majority of punctures were successful on the first attempt (89.3%). The average duration of the procedure was 84.82 ± 31 minutes. A high percentage (89.3 %) of patients did not develop any early complication. One patient had an exit site leak (3.6%) and two patients suffered visceral injuries [intestinal puncture (3.6%) and uterine injury (3.6%)]. The patient who had the uterine injury was also the one who had the intraabdominal bleeding (3.6%).

Table 2: Outcomes and complications.

Outcomes	**Value (n=28)**	**Percentage (%)**
Successful percutaneous insertion of Tenckhoffa		
Yes	28	77.80%
No (failed attempts/converted to open)	8	22.20%

Location of puncturea		
Right paramedian	2	7.10%
Left paramedian	26	92.90%
Midline	0	0%
Number of punctures/attempts		
One (1)	25	89.30%
Two (2)	3	10.70%
Duration of procedure (minutes)	84.82 ± 31.37	
Early complications (≤ 30 days)		
None	25	89.30%
Primary failure	0	0%
Poor initial drainage	0	0%
Peritonitis	0	0%
Exit-site infection	0	0%
Tunnel infection	0	0%
Bleeding		
Intra-abdominal	1b	3.60%
Exit-site	0	0%
Muscle hematoma	0	0%
Exit-site leak	1	3.60%
Scrotal leak	0	0%
Pleural leak	0	0%
Hernia	0	0%
Mechanical catheter dysfunctions	0	0%
Visceral injury		
Intestinal	1	3.60%
Uterine	1	3.60%
Note: (a)All patients attempted to have a percutaneous approach (n=36), (b) Same patient with uterine injury.		

Tables 3 and 4 summarize the variables and factors that may be associated with the development of complications. Only the age was noted to be significantly different from the patients with complications, as compared to the patients without complications (P-value 0.001). Patients with complications were older with a mean age of 68 ± 3.60 years old.

Table 3: Comparison of variables for patients with complications and without complications.

Variable	With complications (n=3)	Without complications (n=25)	P-value
Age (years)	68 ± 3.60	51.24 ± 16.68	0.001
Systolic blood pressure (mmHg)	127 ± 24	123 ± 18	0.785
Diastolic blood pressure(mmHg)	74 ± 3.6	75 ± 10.42	0.744
Weight (kg)	56.67 ± 3.05	59.24 ± 9.66	0.352
BMI (kg/m^2)	22.27 ± 2.5	23.16 ± 3.45	0.617
Hemoglobin (g/L)	8.83 ± 1.116	8.85 ± 2.11	0.982
Platelets (× 109/L)	187 ± 58.66	206 ± 89.98	0.637
WBC (× 109/L)	5.7 (5.47-9.65)	7.23 (5.32-8.70)	0.899
INR	1.17 (1.15-1.20)	1.09 (1.03-1.17)	0.09
Duration of procedure (minutes)	120 (100-120)	75 (60-90)	0.125
Number of punctures	1 (1-1.5)	1 (1-2)	0.944

Table 4: Factors associated with the risk of complications due to percutaneous catheter insertion.

Variable	Odds ratio	Confidence interval	P-value
Previous surgery	1.125	(0.955-1.325)	0.274
BMI ≥ 25 kg/m^2	0.9	(0.778-1.042)	0.353
Diastolic blood pressure(mmHg)	0.92	(0.820-1.033)	0.611
Hemoglobin ≤ 10 g/L	0.474	(0.033-6.744)	0.575
BUN ≥ 60 mg/dl	0.889	(0.755-1.047)	0.274

Discussion

Peritoneal dialysis catheters can be placed surgically through an open or laparoscopic approach; or percutaneously by an interventional nephrologist or interventional radiologist. Some interventional nephrologist can also place it using a peritoneoscope [5]. Although the surgical approach, especially the laparoscopic technique, is considered to be safer than the percutaneous approach, many studies have already demonstrated that there is actually no significant difference in terms of effectiveness and safety. A meta-analysis even stated that a percutaneous approach may even be better in terms of less mechanical dysfunction of the catheter [1]. A percutaneous approach may also have the following advantages: Faster initiation of renal replacement therapy can be placed with only local anesthesia; and lower cost.

Most studies comparing surgical and percutaneous approach do not delineate if the percutaneous approach was done using a blind or an ultrasound-guided technique. In fact, there are still no studies comparing the blind and the ultrasound-guided approach; and it is one of the recommended topics for future research by ISPD [2].

The diagnoses of the patients in our study were generally classified as either chronic kidney disease requiring initiation of renal replacement therapy, or cardiorenal syndrome patients with volume overload and intractable ascites.

The success rate of percutaneous dialysis catheter insertion was 77.8% (28/36). This is lower compared to the research done by Savader, et al. where they reported a technical success rate of 95% (18/19) [6]. A study by Yu, et al. reported a 100% (14/14) technical success rate [7]. Nevertheless, we still think that our success rate is high, considering that our study has a larger

sample size and that our center is a training center. Almost all studies comparing percutaneous and surgical approach involved interventional nephrologists or radiologists who were already well-experienced in their field. Comparing trainees and experienced interventionalists may not be a fair comparison. In addition, the majority of our patients had previous abdominal surgery (55.6%) which potentially made the procedure more challenging. The compared studies have an unbreached abdomen; hence, were criticized for selection bias.

We had two complications which involved injury to the visceral organs (small intestine and uterus). The one with persistent intraabdominal bleeding was the same patient with uterine injury. The incidence of intestinal injury (3.6%) was higher than reported in the literature (<1%) [8]. In a study by Abdel, et al. radiologic percutaneous catheter insertion had a 2%, while a laparoscopic surgical approach had a 0% incidence rate of intestinal perforation [9]. The patient who had intestinal injury was noted to have persistent severe abdominal pain 48 hours after the procedure. This patient had previous abdominal surgery (Tenckhoff insertion) and had a history of peritonitis two months before the procedure. He was eventually noted to have adhesions which may have caused this unfortunate complication. For the patient who had the uterine injury, the bleeding through dialysate fluid continued; hence, explore laparotomy was eventually performed. It was suspected that the metal guide that was used to insert catheter was the one that caused the injury to the uterus.

We also had once case of exit-site leak (3.6%). For the other more common early complications such as poor drainage, exit-site bleeding, muscle hematoma, peritonitis, exit-site infections, tunnel infections and other mechanical dysfunctions, our study had a zero percent (0%) incidence rate. This result is comparable or better than described in the literature.

The image-guided technique (ultrasound with or without fluoroscopy) should be done more frequently and the blind approach should be avoided, as recommended by ISPD 2019 guideline [2]. Ultrasound is readily available in most institutions and there are already many portable ultrasounds available. In the hands of an experienced operator, the outcomes are similar or even better than the surgical technique. Ultrasound can also be used in selecting patients who are better candidates for the percutaneous approach [10].

The current study adds to the emerging literature suggesting that an ultrasound-guided percutaneous approach offers a similar, cost-effective and minimally invasive way of catheter placement. Our study is unique because the operators are trainees (International Society of Nephrology (ISN)-interventional nephrology fellows and nephrology residents) who are still gaining experience on how to perform the procedures. We believe that in a center with dedicated, well-experienced interventional nephrologists, the outcomes would even be better.

The limitations of our study include the following: It is retrospective, descriptive, single-center and has a small sample size. The retrospective nature could result to an inherent selection bias. We recommend that a randomized controlled trial should be done directly comparing an ultrasound-guided approach versus a blind approach, to better establish causality. An ultrasound-guided alone versus ultrasound-guided with fluoroscopy is also an interesting topic that should be considered for future research.

Conclusion

In conclusion, an ultrasound-guided percutaneous placement of peritoneal dialysis catheter can be performed safely and offers a clinically effective alternative to surgical technique. This allows a faster placement of catheters-avoiding the delay of initiation of renal replacement therapy. The majority of the outcomes are similar or better compared to other published literatures. The early complications (visceral injury and intra-abdominal bleeding) noted in our study could be an inherent part of performing procedures in any training institution.

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