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Evaluation of a Training Program in Peritoneal Dialysis Catheter Insertion for Nephrologists in South America

Isabel Cristina Saravia Bermeo[a] Gonzalo Ramírez-Guerrero[b, c] Milene Angulo Juliao[d] Daniel Molina Comboni[e] Cristhian Bueno Lara[f] Maria Adelaida Zapata Zapata[g]

[a]Medical Affairs, Vantive Colombia and South Latin America, Bogota, Colombia; [b]Dialysis and Nephrology Unit, Carlos Van Buren Hospital, Valparaiso, Chile; [c]Nephrology Service, Las Higueras Hospital, Talcahuano, Chile; [d]Nephrology, Davita, Barranquilla, Colombia; [e]Nephrology, Caja petrolera Guaracachi, Santa Cruz de la Sierra, Bolivia; [f]Nephrology, Davita, Cali, Colombia; [g]Clinical Advisor, Vantive, Bogota, Colombia

Keywords
Peritoneal dialysis · Catheter · Education · Kidney replacement therapy · Tutoring · Interventional Nephrology

Abstract

Introduction: For patients requiring renal replacement therapy, peritoneal dialysis (PD) offers an alternative to maintain quality of life. The long-term success of PD depends on using a safe, functional, and durable peritoneal catheter (PC). This study aimed to assess the outcomes of a training program for nephrologists on PD catheter insertion in South American dialysis centers. ***Methods:*** This longitudinal, retrospective, multicenter study was conducted in Colombia, Chile, Ecuador, and Bolivia. Patients who underwent PC insertion between January 2022 and May 2023 were included, with procedures performed by nephrologists trained in a specialized program. Data on population characteristics, procedural details, and catheter function at the first, third, and sixth months were collected. ***Results:*** A total of 117 subjects were included (median age 59 years, 50.4% men). Hypertension and diabetes were the primary causes of kidney disease (34.19% and 49.57%, respectively). Bladder emptying and prophylactic antibiotics were administered before the procedure. Most PC insertions (86.32%) were performed under local anesthesia, with the modified Seldinger technique. Catheter implantation was successful in 96.58% of cases. Elective PD was performed in 69.91% of patients, while 30.01% required urgent PD. Within the first 2 weeks, complications occurred in 7.08% of patients, including catheter tip migration and flow failure. At one, three, and 6 months of follow-up, complications were observed in 1.79%, 3.77%, and 11.00% of patients, respectively. Catheter patency was maintained in 99.10%, 96.22%, and 96.00% of patients at 1, 3, and 6 months, respectively. ***Conclusions:*** Optimal peritoneal access can be achieved through educational programs for nephrologists on catheter insertion, ensuring proper placement and maintenance, and resulting in low complication rates in PD patients.

karger@karger.com
www.karger.com/bpu

Corresponding Author:
Isabel Cristina Saravia Bermeo, isabel.saravia@vantive.com

Introduction

Peritoneal dialysis (PD) is a dialysis technique that offers patients requiring renal replacement therapy (RRT) greater autonomy, a better quality of life and longer survival than hemodialysis [1]. It is also more feasible to use in geographically remote communities, requires less highly trained staff and is cost-saving for healthcare systems [2]. According to the Latin American Registry of Dialysis and Kidney Transplantation, 40,280 patients required PD in 2019, representing 9.3% of patients on RRT. The average PD prevalence in Latin America is 80 patients per million population, but it can be higher in countries, such as Mexico, El Salvador, Guatemala, Costa Rica and Colombia (185 patients per million population) [3], highlighting the impact of kidney disease in these populations and the need to further increase the use of PD.

The long-term success of PD largely depends on the timely placement of a safe, functional, and durable peritoneal catheter (PC) [4]. Catheter complications often lead to catheter loss and contribute to technique failure. Non-modifiable factors, such as advanced age, body mass index, some comorbidities, and other conditions of the insertion technique and methods of connection to the PC must be considered to reduce PD complications [5]. PC migration and obstruction are the main difficulties leading to technical failure and patient withdrawal from the PD program [6].

Despite improvements in insertion techniques and the prevention and treatment of peritonitis, catheter-related infections and mechanical problems with the PC continue to impact PD survival [5]. To prevent complications from PC insertion, the International Society of Peritoneal Dialysis (ISPD) guidelines [7, 8] have recommended best practices for optimal peritoneal access, such as the use of more effective catheters (silicone rubber catheters, double Dacron sheathed polyester catheters, among others), standardization of catheter placement procedures according to type of anesthesia or history of major surgery or peritonitis [8], PC perioperative care and prevention of complications [7].

Expertise in the PC placement technique is acquired with practice, but it is essential to have educational programs that support the performance of this technique to strengthen the learning curve of professionals performing this procedure. For this reason, a Peritoneal Catheter Implantation Program was developed as an academic activity of accompaniment and collaboration during the PC implantation procedure in 6 care centers in four South American countries. This training aimed to strengthen the approach and surgical technique in the context of individualized management of patients diagnosed with chronic kidney disease and treated in the dialysis programs of these specialized centers.

To the best of our knowledge, no results have described the implementation of this type of PC insertion program in the region, so these findings could support the importance of these training spaces and their follow-up in low-middle income countries. In this context, this study aims to describe the results of a PC insertion training program for nephrologists in dialysis centers in South America.

Methods

A longitudinal, retrospective cohort study was conducted in four South American countries: Colombia, Chile, Ecuador, and Bolivia. All adults over 18 years of age who underwent peritoneal catheterization by nephrologists who were part of a specific training program between January 1, 2022, and May 31, 2023, were included in the study. The indication for peritoneal catheterization was indicated by the treating physician as part of usual clinical practice. Patients with a history of previous PC placement, peritonitis, coagulopathies, generalized severe peritoneal calcification, severe polycystic kidney disease, abdominal hernia, morbid obesity, abdominal metastatic disease, those who received radiation therapy, and ventriculoperitoneal shunt carriers were excluded. Cases with incomplete records of outcomes of interest were also excluded.

Training Program

The objective of the program was to train nephrologists in the standardized implantation of PD catheters (PCs), aiming to minimize practice variability, improve procedural success rates, and reduce complications. The program included both face-to-face and virtual sessions, totaling 40 h of training per participant. It comprised 2 courses on PD and PC implantation, covering 10 h, followed by 30 h of hands-on training using both prototypes and real patients. After completing the training sessions, each nephrologist performed 3–4 procedures per day for 2–3 days under the direct supervision of an instructor. Additionally, 1-month post-procedure, the nephrologists received follow-up monitoring and guidance. Following the ISPD guidelines, an annual audit of the insertion outcomes was recommended.

The implantation protocol was divided into four phases: preoperative, preimplantation, intraoperative,

Table 1. Modified Seldinger Technique

Modified Seldinger technique
The percutaneous insertion of a PC involves the following sequential steps • Local anesthesia: infiltrate the skin and subcutaneous tissue with a local anesthetic. • Incision and dissection: make a left lateral incision, 3–4 cm from the umbilicus, avoiding the epigastric artery. Dissect through the subcutaneous tissue (TCS) down to the anterior rectus abdominis aponeurosis. • Muscle infiltration and suturing: infiltrate the fascia and rectus muscle with lidocaine. Place two repair sutures (Vicryl 3-0) approximately 0.5–1 cm apart. • Abdominal cavity access: apply upward traction to the sutures to create a "tenting" effect on the viscera. Using an 80° angled puncture needle directed toward the left iliac fossa, penetrate the posterior fascia while aspirating, then enter the abdominal cavity. • Guidewire insertion: remove the syringe, insert the guidewire through the needle, and then remove the needle. • Dilation and sleeve placement: advance the dilator and sleeve over the guidewire at a 60° angle toward the left iliac fossa until crossing the posterior fascia and reaching the abdominal cavity. • Catheter placement: once proper positioning is confirmed, remove the dilator and metal guide. Introduce the PC through the sleeve up to the first retainer. A Curl Cath catheter (a modified Tenckhoff catheter for acute or chronic PD) is used. This catheter is 57 cm long and has two cuffs. • Liner removal and retainer positioning: fracture and separate the upper portion of the liner while advancing the catheter further. Before complete liner removal, clamp the internal retainer with a small straight mosquito forceps and push it into the anterior rectus muscle, ensuring its proper placement as the liner is fully removed. • Catheter positioning and initial function test: gently pull the catheter to verify the position of the internal retainer. Perform an initial test by instilling 200–400 mL of saline solution, assessing fluid inflow and outflow. • Suture fixation and leakage assessment: tie the repair sutures around the catheter and secure its fixation to the fascia. Conduct a second test with 200–300 mL of saline solution to check for leaks. • Exit site and subcutaneous tunnel formation: create an exit site and subcutaneous tunnel in a gooseneck configuration, positioning the external retainer within the subcutaneous tissue. The tunnel extends 2 cm above the surgical incision and exits 2 cm laterally. • Final catheter test: perform a third catheter test with 200–300 mL of saline solution to confirm proper function. • Final adjustments and wound closure: attach the titanium adapter and transfer line. Ensure hemostasis (using chromic or catgut sutures as needed), then close the surgical wound with Vicryl 3-0 and Prolene 3-0 sutures.

and post-procedure. Each step was documented and reviewed by the nurse using a standardized checklist.

During the preoperative phase, a comprehensive background assessment and physical examination were conducted, followed by the preparation of all necessary materials, selection of the appropriate catheter, and marking of the exit site. Ultrasound was used at this stage to assess the course of the epigastric artery and the relevant anatomical planes, serving as a reference to guide the insertion site.

In the preimplantation phase, patients underwent bowel preparation with a laxative and bladder emptying, either by spontaneous micturition or by the insertion of a bladder catheter in those with diabetes, dysautonomia, or neurogenic bladder. A prophylactic antibiotic was administered prior to the procedure.

The intraoperative phase involved the insertion of the PC using the Modified Seldinger technique (Table 1). No ultrasound guidance was used during peritoneal access. After local anesthesia was administered, the peritoneal cavity was accessed using an 18 G introducer needle and guidewire, followed by tract dilation and catheter placement. The catheter was then tunneled subcutaneously to the previously marked exit site. All procedures were performed using the Medtronic Curl Cath PD catheter kit (2-cuff, 57 cm or 62 cm), which includes: a PC, protective cap, Beta Cap adapter and clamp, 16 Fr Pull-Apart, 18 G introducer needle, #11 scalpel, 12 mL syringe, tunneling stylet, introducer guide, and six $4'' \times 4''$ gauze pads. A pigtail catheter was selected due to its configuration, which allows it to remain in the lower pelvic cavity and reduces the risk of migration. Although current evidence does not show significant differences in outcomes between curved and straight catheters, the pigtail design was preferred in our clinical practice due to its consistent performance and low complication rate.

In the post-procedure phase, the catheter was flushed with dialysis fluid to confirm patency and functionality. An occlusive dressing was applied to the exit site to immobilize the catheter and reduce the risk of infection.

Table 2. Demographic and clinical data of patients in the PC training program

Characteristics	*n* = 117
Age, median (IQR)	59 (15)
Sex (male), *n* (%)	59 (50.43)
Medical history, *n* (%)	
Hypertension	99 (84.62)
Diabetes mellitus	68 (58.12)
Cardiovascular disease (heart attack, arrhythmia, heart failure)	14 (11.97)
Hypothyroidism	3 (2.56)
Obstructive pathology (lithiasis, ureteral stricture, vesicoureteral reflux)	2 (1.71)
Hematologic or solid neoplasm	2 (1.71)
Primary cause of kidney disease, *n* (%)	
Diabetes mellitus	58 (49.57)
Hypertension	40 (34.19)
Indeterminate	6 (5.13)
Glomerular	4 (3.42)
Obstructive	2 (1.71)
Other*	7 (5.98)
Previous abdominal surgery, *n* (%)	15 (12.82)
Cesarean section	5 (4.27)
Cholecystectomy	5 (4.27)
Appendectomy	3 (2.56)
Bariatric surgery	1 (0.85)
Nephrectomy	1 (0.85)
Body mass index, median (IQR)	24.20 (4.66)
Previous hemodialysis, *n* (%)	72 (61.54)

IQR, interquartile range. *Renal agenesis, sickle cell anemia, pyelonephritis, preeclampsia, nephrotic syndrome, tubulointerstitial syndrome, immunologic syndrome.

Data Collection and Analysis

Demographic and clinical variables, including age, sex, medical history, cause of kidney disease, history of abdominal surgery or prior hemodialysis, and body mass index, were collected directly from the medical records. Variables related to the PC insertion procedure – such as prior enema administration, bladder emptying, antibiotic use, type of analgesia or anesthesia, details of the modified Seldinger technique, surgical wound extension, success or failure of implantation – were also recorded, along with the success rate and timing of PD initiation after the procedure. As part of the catheterization follow-up, complications were monitored at 1, 3, and 6 months after placement. A designated investigator at each center recorded the information using a predesigned electronic tool. This registry was anonymized, with each center assigning a unique identifier. Only project researchers had access to the electronic databases.

Descriptive statistics were used for analysis. Categorical variables are presented as frequencies and percentages. For numerical variables, means and standard deviations or medians and interquartile ranges were reported based on the distribution, as assessed by the Kolmogorov-Smirnov test. The Kaplan-Meier analyses were conducted to assess implant survival.

The study was conducted following the Declaration of Helsinki. As an observational study, it involved minimal risk to participants. The Ethics Committees of each participating institution approved the study protocol.

Results

A total of four out of 121 subjects were excluded due to polycystic kidney disease (n = 2), a history of peritonitis (n = 1), or inadequate preparation for the procedure (n = 1, failure to follow laxative instructions). The final sample consisted of 117 patients who underwent PC insertion as part of the training program

Table 3. Characteristics of the PC percutaneous insertion procedure

Characteristics	*n* = 117
Enema before the procedure, *n* (%)	108 (92.31)
Bladder emptying before the procedure, *n* (%)	117 (100)
Use of prophylactic antibiotics, *n* (%)	117 (100)
Cefazolin	58 (49.57)
Cephalothin	40 (34.19)
Ceftriaxone	12 (10.26)
Ceftazidime	6 (5.13)
Vancomycin	1 (0.85)
Type of analgesia/anesthesia during the procedure, *n* (%)	
Local	101 (86.32)
Lidocaine and midazolam	16 (13.68)
Considerations in the modified Seldinger technique*, *n* (%)	
Purse-string suture	2 (1.71)
Surgical wound extension (cm), median (IQR)	4 (1)
Successful implantation, *n* (%)	113 (96.58)
Cause of nonsuccess, *n* (%)	4 (3.42)
Peritoneal cavity access not achieved	2 (1.71)
Bleeding	1 (0.85)
Severe pain	1 (0.85)
Type of PD onset after catheter implantation, *n* (%)	(*n* = 113)
Elective PD	79 (69.91)
Emergency PD (<72 h)	34 (30.09)

PD, peritoneal dialysis; IQR, interquartile range. *Nonexclusive categories.

Table 4. Incidence of complications during PC insertion follow-up

Event	Postprocedural[a] (*n* = 113)	Month 1 (*n* = 112)	Month 3 (*n* = 106)	Month 6 (*n* = 100)
Surgical site infection (ISO)	1 (0.88)	0 (0.00)	0 (0.00)	0 (0.00)
Catheter tip migration	4 (3.54)	1 (0.89)	0 (0.00)	2 (2.00)
Flow failure	3 (2.65)	1 (0.89)	1 (0.94)	2 (2.00)
Peritonitis	0 (0.00)	0 (0.00)	3 (2.83)[b]	7 (7.00)[c]
Total	8 (7.08)	2 (1.79)	4 (3.77)	11 (11.00)

Values are presented as numbers (%). [a]Assessed within 15 days of catheter insertion. [b]Colombia. [c]4 cases from Colombia and 3 cases from Bolivia.

were included between January 1, 2022, and May 31, 2023, across four countries: Colombia (*n* = 71), Bolivia (*n* = 28), Chile (*n* = 14), and Ecuador (*n* = 4). The median age of the patients was 59 years (IQR 15), and 50.43% were men (*n* = 59). Hypertension (84.62%, *n* = 99) and diabetes mellitus (58.12%, *n* = 68) were the most common clinical antecedents. The primary causes of kidney disease were hypertension and diabetes mellitus, accounting for 34.19% (*n* = 40) and 49.57% (*n* = 58) of cases, respectively. A history of abdominal surgery was reported in 12.82% of the subjects (*n* = 15), and 44.44% (*n* = 52) were overweight or obese. A total of 61.54% (*n* = 72) had received hemodialysis for a variable period (median 30 days, IQR 181). The demographic and clinical characteristics of the participants are presented in Table 2.

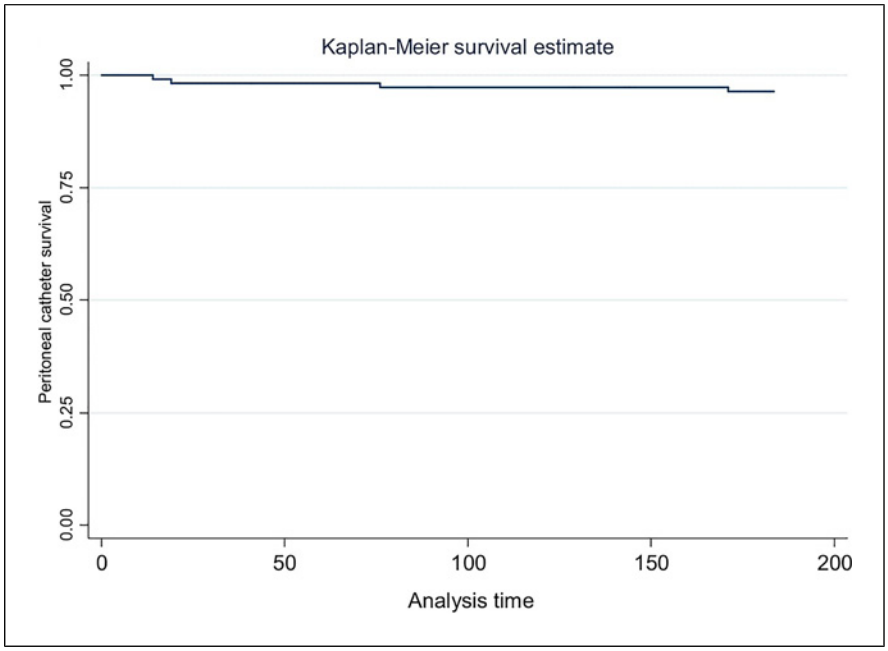

Fig. 1. Survival of the PC 6 months after insertion.

PC Implantation Procedure

Catheter implantation was performed under local anesthesia (86.32%, n = 101) or with a combination of lidocaine and midazolam (13.68%, n = 16). Catheter implantation was successful in 96.58% (n = 113) of the procedures, confirmed by adequate visualization of fluid entry and exit during irrigation with 200–300 mL of normal saline. A total of 69.91% (n = 79/113) of subjects underwent elective PD, while 30.09% (n = 34/113) required emergent PD. In 5.13% (n = 6/117) of subjects, PD was not initiated due to unsuccessful catheter insertion (3.42%, n = 4) or catheter dislodgement (1.71% n = 2). There were no reported cases of leakage. Table 3 provides details of the PC insertion procedure in the study subjects.

Follow-Up of PC Insertion

Of the total number of patients with successful catheter implantation (n = 113), 65 received continuous ambulatory PD and 48 received automated PD. In all cases, the infusion volume ranged from 1,800 to 2,000 mL. A total of 8 complications occurred in 7 (6.19%) patients within the first 2 weeks after the procedure. The most common complications were catheter tip migration (3.54%) and flow failure (2.65%). At 3 months, 2.83% (n = 3) of patients developed peritonitis and 0.94% (n = 1) experienced catheter tip migration. At 6 months, peritonitis was the most common complication, occurring in 7 (7%) patients. Table 4 summarizes the frequency of complications observed during the follow-up period after PC insertion.

Among patients starting PD, catheter patency was maintained in 99.10% (111/112), 96.22% (102/106), and 96.00% (96/100) of subjects at the first, third, and sixth months of follow-up, respectively. PD retention rates were 97.29% (108/111), 98.03% (100/102), and 94.79% (91/96) at months 1, 3, and 6 after catheter implantation, respectively. The survival rate of the PC at 6 months post-placement is shown in Figure 1.

Discussion

A functional PC is the cornerstone of successful RRT and relies heavily on adherence to best practices during insertion to minimize complications and ensure durable access for dialysis [9]. To our knowledge, this is the first study conducted in Latin America that describes the outcomes of a training program for PC insertion aimed at nephrologists in dialysis centers. The results are promising, with a high success rate for the PC insertion procedure (96.58%), and no cases of hollow viscus perforation, leakage, or bleeding events. These results align with the standards proposed by the ISPD, which recommend a complication rate of less than 1% in patients with PCs [10].

In our cohort, slightly fewer than half of the patients had kidney disease secondary to diabetes mellitus, and 14% had undergone abdominal surgery. Half of the unsuccessful catheter implantations were related to adhesions or inability to advance to the abdominal cavity.

These risk factors have been associated with catheter implantation failure and should be considered when selecting patients and anticipating technical difficulties prior to PC insertion [11].

Regarding insertion complications, there were no cases of leakage in our cohort. This finding contrasts with the high rate reported in the literature, which is approximately 12.8% [12]. With respect to infectious events, there was only one case of surgical site infection within the first month among our patients. Previous studies have reported surgical site infection rates as high as 26%, with 50% of these cases leading to catheter removal. [13] Predisposing factors for infection include a weak fibrotic barrier, poor epithelialization of the exit site, non-caudal orientation of the PC outlet, use of a single cuff catheter, local trauma, and lack of daily care of the catheter exit site [13]. In addition, there were no cases of peritonitis within the first month, likely due to standardized safety protocols, including pre-procedure bladder emptying and administration of prophylactic antibiotics, in accordance with ISPD guidelines [10]. Although cases of peritonitis were observed in Colombia and Bolivia (2.83% at 3 months and 7.00% at 6 months), the rates were lower than those reported in studies of late peritonitis incidence, which estimate rates as high as 20% [14]. To minimize the occurrence of late infections after PC insertion, it is essential to reinforce daily catheter care protocols at home through training and retraining programs for both patients and healthcare professionals [15].

According to the literature, catheter-related events account for approximately 11% of PD interruptions [11]. In the follow-up conducted in this study, 97.29% of patients remained on dialysis with a functional catheter during the first month. Six months after catheter implantation, 94.7% of patients were still on dialysis. The main causes of catheter malfunction were catheter tip migration and flow failure. Catheter migration can occur at any time after placement and has been reported in 12.7%–35% of patients in previous studies [16]. Our lower rates of catheter migration highlight the importance of appropriate catheter placement and monitoring techniques.

Previous meta-analyses evaluating the outcomes of PC insertion techniques have shown that compared to surgical techniques, percutaneous insertion is significantly associated with a lower risk of exit site infection and peritonitis (within 1 month of the procedure), as well as lower rates of catheter migration and removal, with no difference in mechanical complication rates [17, 18]. These findings have implications for the management of PD programs and underscore the importance of training in percutaneous techniques to achieve optimal outcomes. Furthermore, nephrologist-initiated PD access programs have been associated with higher primary success rates, longer catheter survival, less postoperative pain, shorter hospital stays, and faster catheter adaptation compared to conventional surgical approaches [19]. Additionally, a multicenter study demonstrated that catheter insertion by nephrologists can positively impact access to and utilization of PD [20].

The results of this study demonstrate how an educational program for nephrologists can achieve a high rate of PC insertion success and PC survival. These benefits are maximized when centers adhere to strict infection control protocols and nephrologists collectively adopt a standardized insertion technique [2]. In order to reduce complications associated with PC placement [21], continuous quality improvement programs have been implemented, showing that standardizing procedures and follow-ups can enhance treatment effectiveness. A Cochrane systematic review suggested that each renal care center should develop a protocol for PC insertion based on local experience and ensure that adequate audit measures are in place to monitor outcomes at each center [22]. Therefore, nephrology education programs should include instruction on the benefits and limitations of each dialysis modality, which has been associated with increased PD practice and significantly better outcomes, such as reduced hemodialysis catheter use [23].

The percutaneous placement of PD catheters compares favorably with basic and advanced laparoscopic techniques and open surgical approaches [7]. Therefore, the choice of technique should be based on individual patient assessment, physician expertise, risk-benefit analysis, and resource availability. A pragmatic and widely adopted approach is to use the percutaneous method for appropriate candidates while reserving advanced laparoscopic techniques for patients with a history of major abdominal surgery, catheter dysfunction, or the need for a second catheter [24]. Interdisciplinary collaboration between surgery, nephrology, and other specialties can facilitate the standardization of procedures and optimize outcomes based on the selected technique.

This study has several limitations inherent to retrospective designs. Certain aspects, such as postoperative medical management, followed the protocols established by each center. These were not included in the study due to the heterogeneity of the available data. As strengths, close clinical monitoring of study subjects was conducted as part of routine clinical practice. Standardized catheter insertion and monitoring protocols were followed based on current clinical practice guidelines. Additionally, this multicenter study included over 100 patients from various South

American countries, demonstrating the broad applicability and potential benefits of these practices in the region. Future research should include economic evaluations to determine the cost-effectiveness of implementing these educational strategies in renal care centers.

Conclusions

Optimal peritoneal access can be achieved through the implementation of educational programs that equip healthcare providers with the necessary skills for proper implantation and successful maintenance of the PC, thereby reducing complications in PD. Minimizing complications and ensuring catheter survival can enhance dialysis adherence in resource-limited regions where this procedure is widely utilized.

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Statement of Ethics

The study was conducted following the Declaration of Helsinki. As an observational study, it involved minimal risk to participants. This study protocol was reviewed and approved by Medical Ethics Committee of INCOR$_{S.R.L}$ Clinic, Santa Cruz, Bolivia, Approval No. 0100 (December 4, 2023). The committee waived the requirement for informed consent, as this was a registry-based study utilizing data from a program in which patients had already provided informed consent for the relevant procedures.

Conflict of Interest Statement

I.C.S.B. works at Vantive Colombia and South Latin America. M.A.Z.Z. works at Vantive Colombia. All other authors have no conflicts of interest to declare.

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Author Contributions

I.C.S.B., G-R.-G., M.A.J., D.M.C., C.B.L., and M.A.Z.Z.: conception and design, analysis and interpretation of data, critical review of content, and final approval of the manuscript.

Data Availability Statement

All data generated or analyzed during this study are included in this article. Further inquiries can be directed to the corresponding author.

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