The Effect of Obesity on Outcomes of Percutaneous Peritoneal Dialysis Catheter Insertion by Interventional Radiologists

Olivier Houle, MD, Clément Vachey, MD, MPH, Émilie Vincent-Blouin, Juliette Samson, Mathieu Rousseau-Gagnon, MD, Fabrice Mac-Way, MD, and Guillaume Garneau, MD

ABSTRACT

Purpose: To assess the feasibility and safety of percutaneous peritoneal dialysis (PD) catheter insertion in obese patients.

Materials and Methods: This single-center retrospective study included 125 consecutive patients who underwent PD catheter insertion by an interventional radiologist. Patients were categorized by body mass index (BMI): <25 kg/m^2 (normal weight, n = 61), 25–29.9 kg/m^2 (overweight, n = 40), and ≥30 kg/m^2 (obese, n = 24). Most obese patients had Class I obesity (BMI, 30–34.9 kg/m^2), with only 2 having a BMI of >35 kg/m^2. Catheter-related adverse events within 1 year were recorded. The primary outcome was catheter failure (replacement, surgical repositioning, or PD discontinuation due to dysfunction). Death, transplantation, and renal recovery were considered competing events. Failure risk was assessed using the cumulative incidence function, and the effect of BMI categories was estimated by a Fine and Gray model. Adverse events were analyzed using a robust Poisson method.

Results: Within 1 year, 36 catheter failures (28.8%) occurred, 3 patients died, and 7 underwent kidney transplantation before catheter failure. BMI was not significantly associated with catheter failure (subdistribution hazard ratios, overweight, 0.89 [95% CI, 0.45–1.78], and obese, 0.60 [95% CI, 0.23–1.59]). Sixty patients (48.0%) experienced at least 1 adverse event: 50.8%, 50.0%, and 37.5% in normal-weight, overweight, and obese patients, respectively (relative risk obese vs normal, 0.75 [95% CI, 0.41–1.36]).

Conclusions: Class I obesity was not associated with a higher risk of adverse events, supporting the safety and feasibility of percutaneous PD catheter insertion. However, these findings should be interpreted with caution given the limited sample size.

ABBREVIATIONS

BMI = body mass index, CT = computed tomography, PD = peritoneal dialysis, SMD = standardized mean difference, WHO = World Health Organization

End-stage kidney disease represents the final stage of progression in patients with chronic kidney disease. Peritoneal dialysis (PD) is one of the therapeutic options available for these patients. The number of patients treated with PD has been increasing, due, in part, to its advantages over hemodialysis, including improved quality of life, autonomy, cost-effectiveness, and preservation of residual kidney function (1–5). PD requires the placement of a catheter in the abdominal cavity to allow the exchange of dialysate and convective clearance across the peritoneal membrane (6). PD catheters can be inserted surgically or percutaneously. Historically, surgical insertion has been the preferred method; however, the percutaneous approach has demonstrated comparable catheter survival rates and adverse events (7). Because it does not require an operating room or general anesthesia, the percutaneous approach is more cost-effective and accessible than the surgical approach (7). However, some relative contraindications to percutaneous insertion remain, including a high body mass index (BMI), although this is still debated in the literature (8–10). Obesity is commonly categorized using the World Health Organization (WHO) classification, with Class I defined as a BMI of 30–34.9 kg/m^2, Class II as a BMI of 35–39.9 kg/m^2, and Class III as a BMI of ≥40 kg/m^2, which helps set expectations regarding outcomes across different obesity severities. With the increasing prevalence

Table E1 can be found by accessing the online version of this article on *www.jvir.org* and selecting the Supplemental Material tab.

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RESEARCH HIGHLIGHTS

- Obesity raises concern about the safety and effectiveness of percutaneous peritoneal dialysis catheter insertion.
- In this single-center retrospective study, 125 patients underwent catheter insertion by an interventional radiologist. Patients were categorized by body mass index: normal weight, overweight, and obese.
- One-year catheter failure occurred in 28.8%, with no significant difference between body mass index groups.
- Nearly half of patients experienced at least 1 adverse event; however, adverse event rates were not higher in obese patients.
- Findings support the safety and feasibility of percutaneous peritoneal dialysis catheter insertion in obese patients.

of obesity worldwide, evaluating the safety and effectiveness of percutaneous catheter insertion in this population is essential to determine whether more patients could benefit from this approach.

The aim of this study was to compare the risk of catheter failure between obese and nonobese patients undergoing percutaneous PD catheter insertion.

MATERIALS AND METHODS

Design and Population

This retrospective study included all patients who consecutively underwent percutaneous PD catheter insertion at the CHU de Québec, Hôtel-Dieu de Québec hospital between September 2014 and June 2022. Data were collected from patients' electronic medical records until June 2023 to ensure a minimum follow-up period of 12 months. The patients were divided in 3 groups based on their BMI: Group 1, <25 kg/m^2; Group 2, ≥25 and <30 kg/m^2; and Group 3, ≥ 30 kg/m^2. Informed consent was not required for this study due to its retrospective design and the use of de-identified patient data, as approved by the research ethics committee (CHU de Québec, Université Laval).

Baseline Patient's Characteristics

From March 2014 to June 2022, 139 percutaneous PD catheters were inserted. A total of 125 patients were included in this study; 14 were excluded due to unavailable follow-up data. Population characteristics are described in Table 1. The mean age was 55.5 years (± 17.3 SD) , and 54 (43.2%) were women. The mean BMI was 25.6 kg/m^2 (± 5.0 SD) , with 61, 40, and 24 patients classified as normal weight, overweight, and obese, respectively. Most patients in the obese group had Class I obesity (BMI, 30–35 kg/m^2), with only 2 patients exceeding a BMI of 35 kg/m^2. A significantly higher proportion of patients with diabetes were observed in the overweight and obese groups (47.5% and 70.8%, respectively) compared with 26.2% in the normal-weight group (standardized mean difference [SMD], 0.45 and 1.00). Imbalances were also noted in alcohol consumption and smoking habits, with higher prevalence in overweight and obese patients (SMDs of 0.31 and 0.34 for alcohol and 0.20 and 0.14 for smoking, respectively). PD was initiated a mean of 44 days (± 33 SD) after catheter insertion, with a slightly longer delay in the overweight group (SMD, 0.19).

Table 1. Population Characteristics according to Body Mass Index Categories

Variables	BMI categories			Standardized mean differences (a BMI of <25 kg/m^2 is the reference)	
	<25 kg/m^2 *n* = 61	25–29.9 kg/m^2 *n* = 40	≥30 kg/m^2 *n* = 24	25–29.9 kg/m^2	≥30 kg/m^2
Age (y)	53.0 ± 18.9	60.5 ± 14.4	53.6 ± 16.2	0.45	0.04
Women (%)	31 (50.8)	15 (37.5)	8 (33.3)	−0.27	−0.36
BMI (kg/m^2)	21.6 ± 2.2	26.9 ± 1.2	33.5 ± 2.9	3.02	4.68
Comorbidities					
Diabetes	16 (26.2)	19 (47.5)	17 (70.8)	0.45	1.00
Hypertension	54 (88.5)	35 (87.5)	22 (91.7)	−0.03	0.11
Dyslipidemia	42 (68.9)	30 (75.0)	19 (79.2)	0.14	0.24
Health habits					
Smoking	23 (37.3)	21 (52.5)	13 (54.2)	0.31	0.34
Alcohol	3 (4.9)	4 (10.0)	2 (8.3)	0.20	0.14
Laboratory					
Hemoglobin (g/L)	104.5 ± 12.3	104.3 ± 11.7	107.9 ± 14.6	−0.02	0.25
Platelets (× 10^9/L)	206.0 ± 78.1	200.5 ± 66.0	215.1 ± 70.4	−0.08	0.12
Creatinine (µmol/L)	557.0 ± 160.8	552.7 ± 173.6	646.0 ± 243.2	−0.03	0.43
Delay from catheter insertion to dialysis start (d)	42.6 ± 33.2	49.3 ± 40.2	40.3 ± 17.2	0.19	−0.08

Note–Data are presented as means ± SD or n (%); an absolute standardized mean difference of >0.10 was considered indicative of a meaningful imbalance. BMI = body mass index.

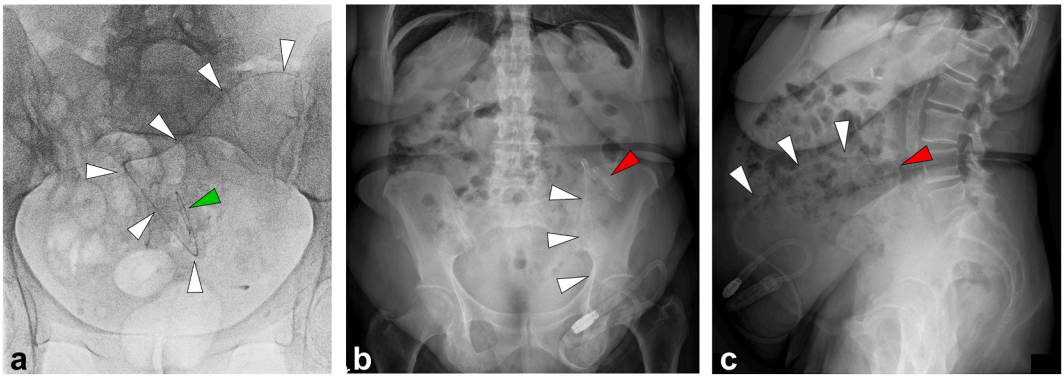


Figure 1. Catheter displacement in an obese patient. **(a)** Fluoroscopic image showing course (white arrowheads) and coiled tip (green arrowhead) after proper placement of the peritoneal dialysis catheter within the pelvic cavity. **(b)** Anteroposterior and **(c)** lateral abdominal radiograph demonstrating displacement of the peritoneal dialysis catheter tip to the left iliac fossa (red arrowhead).

Catheter Insertion Procedure

Argyle PD catheters (Argyle; Medtronic, Minneapolis, Minnesota), featuring a double cuff, swan-neck configuration, and curled intraperitoneal segment, were percutaneously inserted under local anesthesia and moderate sedation by a single interventional radiologist (G.G.). At the initiation of the PD catheter program in 2014, the operator (G.G.) had 7 years of experience in interventional radiology but no prior specific experience in PD catheter placement. The technique has been previously described by Brunier et al (11). Briefly, an incision was made lateral to the umbilicus, and the peritoneal cavity was accessed with a needle using the Seldinger technique under fluoroscopic and sonographic guidance. Using a peel-away introducer sheath, the PD catheter was inserted over a metallic stylet, and the tip was placed in the most dependent portion of the pelvis. The deep cuff was then sutured to the rectus fascia, and the extraperitoneal part of the PD catheter was tunneled under the skin at an inferolateral angle. Abdominal and pelvic computed tomography (CT) was conducted prior to the intervention to screen for any abnormalities in the abdominal wall or cavity that could limit the procedure, such as abdominal wall hernias or intra-abdominal masses. Anticoagulants and antiplatelet medications were discontinued prior to the intervention according to standard practice and in accordance with the Society of Interventional Radiology Consensus Guidelines for the Periprocedural Management of Thrombotic and Bleeding Risk in Patients Undergoing Percutaneous Image-Guided Interventions-Part II (12). Warfarin was held 4–5 days prior with confirmation of an appropriate international normalized ratio, direct oral anticoagulants were withheld 24–48 hours before when renal function permitted, and antiplatelet agents (eg, aspirin and clopidogrel) were held 5–7 days prior, whereas individual thrombotic and bleeding risks were considered in a shared decision-making process. Coagulation parameters were assessed on the morning of the intervention to ensure safe hemostasis. Prophylactic intravenous antibiotics (cefazolin 2 g or vancomycin 15 mg/kg in case of known allergy or methicillin-resistant *Staphylococcus aureus* colonization) were administered prior to the procedure. Patients were monitored for approximately 4 hours and discharged on the same day in the absence of adverse events. PD was initiated 4 weeks after insertion based on evaluation by the nephrology team.

Data Collection and Outcomes

Data were collected from each patient's electronic medical record. Baseline characteristics included age, sex (men or women), BMI, comorbidities (diabetes, hypertension, and dyslipidemia), health habits (smoking and alcohol consumption), and laboratory values (hemoglobin, platelets, and creatinine). The primary outcome was time to catheter failure within the first 12 months after insertion, irrespective of whether adverse events occurred during this period. Catheter failure was defined as the need for complete catheter replacement, surgical repositioning, or discontinuation of PD due to catheter dysfunction. Secondary outcomes included all adverse events occurring within the first 12 months after insertion. Adverse events occurring within 30 days of catheter placement were classified as early adverse events; those occurring afterward were classified as late adverse events. Adverse events were categorized as mechanical or infectious (13). Mechanical adverse events included flow dysfunction (eg, extrinsic compression of the catheter tip, internal luminal obstruction, migration, or entrapment by surrounding tissue) as well as leakage issues (eg, pericatheter leaks, abdominal wall hernia, or pleuroperitoneal fistula). Infectious adverse events included exit-site infection, tunnelitis, and peritonitis. Any adverse events not fitting these categories were classified as "other." An example of catheter migration in an obese patient is shown in **Figure 1a–c**.

All adverse events were reclassified and reported according to the modified Society of Interventional Radiology (SIR) adverse event classification system (14).

Table 2. Catheter Failure during First Year after Catheter Insertion according to Body Mass Index Categories

Variables	BMI categories			Total
	<25 kg/m^2 n = 61	25–29.9 kg/m^2 n = 40	≥30 kg/m^2 n = 24	N = 125
Catheter failure	19 (31.1)	12 (30.0)	5 (20.8)	36 (28.8)
Time to catheter failure*, mo	4 (3–6)	5.5 (5–7.5)	7 (4–8)	5 (3–7)
Competing events	5 (8.2)	4 (10.0)	1 (4.2)	10 (8.0)
Death	2 (3.3)	1 (2.5)	0	3 (2.4)
Kidney transplant	3 (4.9)	3 (7.5)	1 (4.2)	7 (5.6)
Renal function recovery	0	0	0	0
Subdistribution hazard ratios for catheter failure (95% CI)†	Reference	0.89 (0.45–1.78), *P* = .74	0.60 (0.23–1.59), *P* = .31	NA

Note– Data are presented as medians (interquartile ranges) or n (%).
BMI = body mass index; NA = not available.
*Estimated in individuals experiencing a catheter failure by median and interquartile range.
†Univariate analysis with a Fine and Gray model.

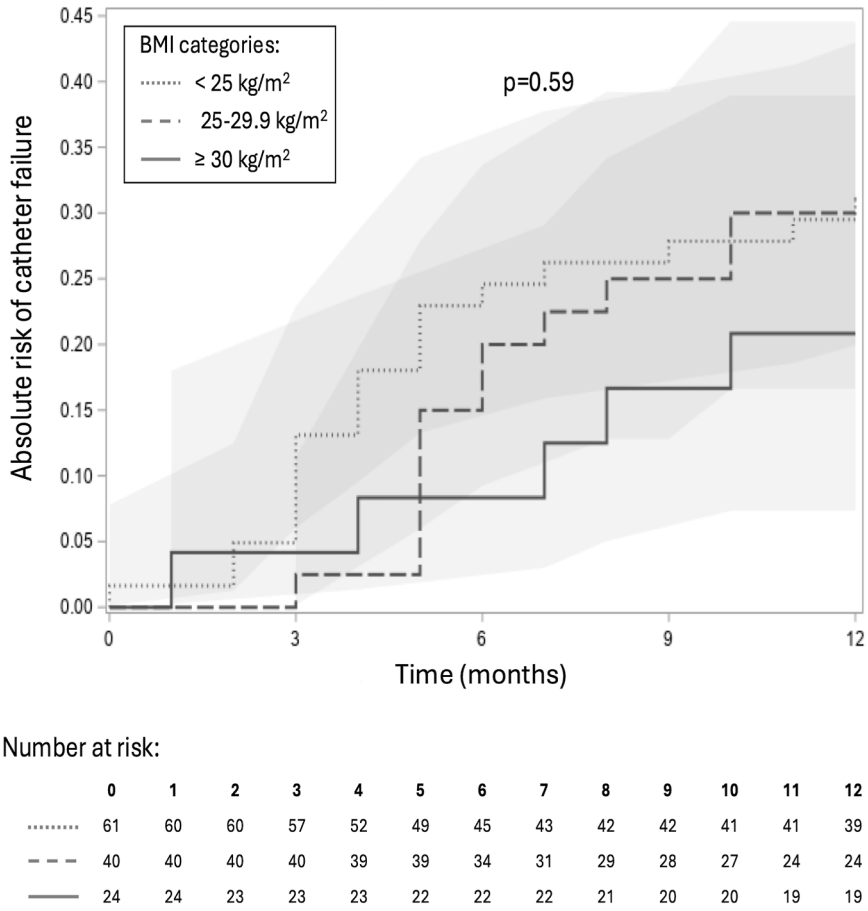


Figure 2. Absolute risk of catheter failure according to body mass index (BMI) categories during the first year after catheter insertion, estimated with the cumulative incidence function (CIF). CIFs were estimated considering the following competing events: death, kidney transplant, and peritoneal dialysis withdrawal for renal function recovery. CIFs were compared with the Gray test. Among 125 patients, 36 experienced a catheter failure, and 10 experienced a competing event.

Statistical Analyses

Continuous variables were summarized as means and SDs or medians and interquartile ranges, and categorical variables were summarized as counts and percentages. Population characteristics were compared between BMI groups using SMD, with an absolute SMD of >0.10 considered indicative of a meaningful imbalance. Time to catheter failure, as previously defined, was assessed using the cumulative incidence function, accounting for death, kidney transplantation, and PD withdrawal due to renal function recovery as competing events (15). Cumulative incidence functions were compared using the Gray test, and

Table 3. Peritoneal Dialysis-Related Complications during First Year after Catheter Insertion, according to Body Mass Index Categories

Variables	BMI categories			*P* values*	Total
	<25 kg/m² n = 61	25–29.9 kg/m² n = 40	≥30 kg/m² n = 24		n = 125
Patients experiencing at least 1 complication, n (%)	31 (50.8)	20 (50.0)	9 (37.5)	0.52	60 (48.0)
Relative risk‡, univariable model	Reference	0.98 (0.66–1.46)	0.74 (0.42–1.31)		
Relative risk‡, multivariable model§	Reference	1.02 (0.67–1.54)	0.75 (0.41–1.36)		
Patients experiencing at least 1 early complication (≤30 d), n (%)	5 (8.2)	0	4 (16.7)	0.03	9 (7.2)
Mechanical complications	0	0	0		0
Flow dysfunction	0	0	0		0
Leakage/hernia issues	0	0	0		0
Catheter migration	0	0	0		0
Infectious complications	5 (8.2)	0	3 (12.5)		8 (6.4)
Exit-site infection	1	0	2		3
Tunnelitis	0	0	1		1
Peritonitis	4	0	1		5
Hemorrhagic complication	0	0	0		0
Others	0	0	1		1
Patients experiencing at least 1 late complication (>30 d, up to 12 mo), n (%)†	29 (47.5)	20 (50.0)	6 (25.0)	0.11	55 (44.0)
Mechanical complications‖	17 (26.2)	6 (15.0)	2 (8.3)		25 (20.0)
Flow dysfunction	1	3	1		5
Leakage/hernia issues	6	1	1		8
Catheter migration	10	2	0		12
Infectious complications‖	11 (18.0)	15 (37.5)	5 (20.8)		31 (24.8)
Exit-site infection	2	2	1		5
Tunnelitis	2	1	3		6
Peritonitis	8	12	4		24
Hemorrhagic complication	0	0	0		0
Others	1	2	0		3

BMI = body mass index.
*Estimated with a chi-square test or Fisher exact test.
†Some patients have experienced several complications.
‡Estimated using a robust Poisson regression.
§Adjusted for age, diabetes, and smoking.
‖Not mutually exclusive.

subdistribution hazard ratios for BMI categories were estimated using a Fine and Gray model (with a BMI of <25 kg/m^2 as the reference). Adverse events were reported according to BMI group. The proportion of patients experiencing at least 1 adverse event was compared using the chi-square test or Fisher exact test for early, late, and overall adverse events. Relative risks for BMI categories were estimated using robust Poisson regression (BMI of <25 kg/m^2 as the reference) (16). Both univariable and multivariable models were performed, adjusting for age, diabetes, and smoking status. All statistical analyses were conducted using SAS version 9.4 (SAS Institute, Cary, North Carolina). A *P* value of <.05 was considered statistically significant.

RESULTS

Catheter Survival

During the first 12 months after catheter insertion, 36 catheter failures (28.8%) were observed, occurring in 19 (31.1%), 12 (30.0%), and 5 (20.8%) patients in the normal-weight, overweight, and obese groups, respectively (Table 2). The median time to catheter failure was 5 months (interquartile range, 3–7 months). There were 3 deaths and 7 kidney transplants.

The cumulative incidence function by BMI category is shown in Figure 2, with no significant differences observed between groups ($P = .59$). In univariate analysis, the subdistribution hazard ratios for catheter failure compared with the normal-weight group were 0.89 (95% CI, 0.45–1.78) for overweight patients and 0.60 (95% CI, 0.23–1.59) for obese patients.

PD Catheter Adverse Events

Infectious and mechanical adverse events occurring within 12 months are presented in Table 3. During the first year following catheter insertion, 60 patients (48.0%) experienced at least 1 adverse event: 31 (50.8%) in the normal-weight group, 20 (50.0%) in the overweight group, and 9 (37.5%) in the obese group ($P = .52$). BMI was not significantly associated with the risk of

experiencing at least 1 adverse event in either univariable or multivariable analysis, with relative risk of 1.02 (95% CI, 0.67–1.54) for overweight patients and 0.75 (95% CI, 0.41–1.36) for obese patients.

Regarding the timing of adverse events, 9 patients (7.2%) experienced at least 1 early adverse event, including 8 patients (6.4%) with infectious adverse events. Early adverse events tended to be slightly more frequent in obese patients (16.7%) than in normal-weight (8.2%) and overweight (0%) groups ($P = .03$). Concerning late adverse events, 55 patients (44.0%) experienced at least 1 late adverse event. Late adverse events were less frequent in the obese group (25%) compared with those in the normal-weight (47.5%) and overweight (50.0%) groups, although this difference did not reach statistical significance ($P = .11$).

No fatal or life-threatening adverse events were observed in the cohort, as classified according to the modified SIR adverse event system. A detailed summary of all adverse events, including early and late events stratified by severity and BMI category, is provided as supplementary data (**Table E1**, available online on the article's Supplemental Material page at *www.jvir.org*).

DISCUSSION

In this study, catheter survival rates and adverse events following percutaneous PD catheter insertion by an interventional radiologist were comparable among normal-weight, overweight, and obese patients. Although the total number of early adverse events in obese patients was small, a slightly higher proportion was observed compared with normal-weight and overweight patients. The slightly higher rate of early adverse events in obese patients may reflect technical challenges related to deeper abdominal wall and subcutaneous fat, which can increase mechanical risks such as tip malposition or leakage. Additionally, increased tissue depth and skin folds may contribute to early infectious adverse events by making exit-site care more challenging, although overall adverse events and catheter survival remained comparable. Although PD in obese patients presents its unique challenges (17,18), the initial critical step is ensuring a functional dialysis catheter to allow dialysate exchanges. Percutaneous catheter insertion is more accessible than the surgical option and allows easier recovery. This technique has previously demonstrated its safety, with outcomes and adverse event rates comparable to those of the surgical approach (7).

Until today, the use of percutaneous insertion in obese patients is still perceived as a relative contraindication. The rationale is that a protuberant obese abdomen is more mobile, which could increase the risk of displacement of the subcutaneous, intramuscular, and intraperitoneal segment of the catheter. Such displacement could predispose the catheter to mechanical obstruction and leakage (19). Early evaluation of catheter survival in obese patients was primarily based on surgical insertion technique. Krezalek et al (9) examined 3 surgical approaches and found that obesity was not associated with higher adverse event rates or shorter catheter survival. More recently, Xie et al (10) assessed both surgical and percutaneous techniques in obese patients (BMI, >28 kg/m^2) and demonstrated no significant association between obesity and adverse outcomes, with similar catheter survival rates observed across groups.

Early adverse events were infrequent across the 3 BMI groups, which may be explained by the initiation of PD exchanges no earlier than 30 days after catheter insertion. The proportion of early infectious adverse events observed (6.4%) was consistent with data available in the literature. Agarwal et al (7), in a systematic review and meta-analysis of percutaneous and surgical PD catheter insertion from 1990 to 2016, reported a mean early infectious adverse event rate of 6.96% for percutaneous insertions. Similarly, the overall proportion of infectious adverse events observed (29.6%) closely matched the 36.23% reported by Agarwal et al (7). Although no early mechanical adverse events occurred in this study, the rate of late mechanical adverse events (20.0%) was also in line with previously reported rates (15.27%) (7).

This study has some limitations. It was conducted retrospectively at a single-center and performed by a single operator, which may limit external validity and introduce potential selection bias. In addition, the number of obese patients was relatively small (n = 24), which limited the power of the analyses. Most obese patients had Class I obesity, with only 2 patients having a BMI of >35 kg/m^2, which limits the ability to draw conclusions for individual with more severe obesity. At this study center, patients with obesity Class ≥2 were likely directed to surgical catheter insertion or even to hemodialysis instead of percutaneous insertion. Additionally, BMI is an imperfect surrogate for body habitus, as the same value can reflect very different anatomical characteristics, particularly regarding fat distribution and muscle mass and it represents only a crude proxy for other underlying pathophysiological mediators. Alternative anthropometric measures may provide more meaningful predictive insights. For example, waist circumference more directly reflects abdominal adiposity (20), whereas parameters such as skin-to-peritoneum distance or rectus abdominis muscle thickness have also been proposed as relevant markers (21). Intraperitoneal pressure may be another important factor potentially involved in catheter failure, and it is positively associated with BMI (22,23), likely through its correlation with visceral fat. Elevated intraperitoneal pressure has been associated with an increased risk of adverse events such as hernias and dialysate leakage in PD (24,25). However, intraperitoneal pressure can only be reliably measured once PD has commenced, not prior to catheter insertion. Further studies should aim to assess the predictive value of these morphometric parameters for catheter and technique survival, with the goal of improving patient care, refining patient selection, and individualizing catheter placement strategies (26). Current evidence indicates that patients should be evaluated individually before being directed to percutaneous or surgical catheter insertion, and BMI alone

should not be used as a criterion to exclude percutaneous insertion.

In this observational cohort of PD patients with percutaneously inserted catheters, obesity was not associated with an increased risk of catheter failure or PD-related adverse events during the first year of dialysis. These findings suggest that offering this catheter placement technique to patients with Class I obesity is both safe and feasible. However, these results should be interpreted with caution given the retrospective, single-center design and the limited number of patients with more severe obesity.

AUTHOR INFORMATION

From the Diagnostic Radiology Department (O.H., G.G.), CHU de Québec, Université Laval, Québec City, Québec, Canada; and Research Center of CHU de Québec (C.V., M.R.-G., F.M.-W.), Hôtel-Dieu de Québec Hospital, Division of Nephrology, Nephrology and Endocrinology Axis, Faculty and Department of Medicine, and Faculty and Department of Medicine (É.V.-B., J.S.), Université Laval, Québec City, Québec, Canada. Received August 28, 2025; final revision received November 28, 2025; accepted December 8, 2025. Address correspondence to O.H., Department of Diagnostic Radiology, Université Laval, 1050, avenue de la Médecine, Québec City, Québec, Canada G1V 0A6; E-mail: olivier.houle.4@ulaval.ca

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