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Analysis of ultrafiltration volume during long dwell with icodextrin in automated peritoneal dialysis

(Analyse de l'ultrafiltration pendant la stase longue sous icodextrine en dialyse péritonéale automatisée)

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Abstract

Icodextrin's sustained colloid osmotic properties drive its ultrafiltration capacity in the peritoneal cavity, facilitating effective fluid volume management by regulating reabsorption. However, its efficacy fluctuates during prolonged dwell periods in automated peritoneal dialysis (APD), posing challenges and increasing the risk of treatment failure. This study examines negative ultrafiltration (UF) during daytime dwell in APD patients using icodextrin and aims to identify associated factors. A retrospective observational monocentric study on UF during prolonged icodextrin dwell periods in APD was conducted among 27 incident patients at the University Hospital of Caen in Normandy, France. The primary focus was the presence of negative daytime UF, with intraperitoneal pressure (IPP) as the main exposure variable. Statistical analyses, including group comparisons and univariate and multivariate logistic regressions, explored associations between negative daytime UF, IPP, and other relevant variables. While no variable showed a significant correlation, IPP (OR=1.06), Volume of the last injection (OR=0.97), and Body Mass Index (OR=0.97) exhibited interesting trends. The multivariate analysis showed no significant association between the variables and negative daytime UF. Nevertheless, IPP was the only variable that improved the model's quality, suggesting a potential link for further exploration. This study raises important questions for future research and clinical practice regarding the systematic measure of the IPP during peritoneal dialysis treatments, despite its limitations, which include the small sample size size and the retrospective observational nature of the methodology, affecting the statistical power and the ability to establish causal links.

Keywords: Peritoneal Dialysis, Automated Peritoneal Dialysis, Chronic Kidney Disease, Icodextrin, Intraperitoneal Pressure, Ultrafiltration

Résumé

Les propriétés osmotiques colloïdales soutenues de l'icodextrine alimentent sa capacité d'ultrafiltration dans la cavité péritonéale, favorisant ainsi une gestion efficace du volume de fluide en régulant la réabsorption. Toutefois, des variations persistent lors de périodes de stase prolongée en dialyse péritonéale automatisée (DPA), ce qui constitue un défi clinique et accroît le risque d'échec de traitement. Cette étude vise à examiner les phénomènes d'ultrafiltration (UF) négative durant la stase diurne chez les patients en DPA sous icodextrine, ainsi qu'à identifier les facteurs associés à cette occurrence. Une étude rétrospective observationnelle monocentrique sur l'UF réalisée pendant les périodes de stase prolongée d'icodextrine en DPA a été menée auprès de 27 patients incidents au Centre Hospitalier Universitaire de Caen en Normandie, France. L'événement principal était la présence d'une UF diurne négative, avec la pression intrapéritonéale (PIP) comme variable d'exposition. Les analyses statistiques, y compris des comparaisons entre groupes, des régressions logistiques univariées et multivariées, ont été réalisées. Bien que la corrélation entre les variables et l'UF diurne négative n'ait pas été significative, la PIP (OR=1,06), le Volume de la dernière injection (OR=0,97) et l'Indice de Masse Corporelle (OR=0,97) présentent des tendances intéressantes. L'analyse multivariée n'a pas révélé d'association significative entre les variables et l'UF diurne négative. Néanmoins, la PIP s'est avérée être la seule variable à améliorer la qualité du modèle, suggérant un lien potentiel qui nécessite une exploration plus approfondie. Malgré le fait que la mesure de la PIP ne soit pas systématique dans les centres de dialyse, cette étude suggère ses avantages en cas de variabilité de l'UF sous DPA, soulevant ainsi des questions importantes pour la recherche future et la pratique clinique. Les limites de l'étude, notamment la taille restreinte de l'échantillon et la nature observationnelle rétrospective de la méthodologie, affectent la puissance statistique et la possibilité d'établir des liens de causalité.

Mots-clés : Dialyse péritonéale, Dialyse péritonéale automatisée, Insuffisance rénale chronique, Icodextrine, Maladies Rénales Chroniques, Pression Intrapéritonéale, Ultrafiltration

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Introduction

In 2022, only 6% of patients in stage 5 chronic kidney disease (CKD) in France were treated with peritoneal dialysis (PD), which highlights its relatively low adoption rate [1]. Automated peritoneal dialysis (APD), however, remains a cornerstone therapy for managing end-stage kidney disease (ESKD), offering flexibility and effectiveness in achieving fluid and solute clearance [2–6]. APD provides several benefits, particularly for patients requiring urgent initiation of dialysis, as it has been associated with a lower incidence of PD-related complications compared to urgent start of hemodialysis. [7]

However, challenges persist in the effective use of APD, particularly in addressing negative daytime ultrafiltration (UF) when icodextrin is used [8–11]. Icodextrin, a complex polysaccharide solution, is widely used in PD for its ability to sustain UF during long daytime dwell periods and reduce glucose-related complications [11–16]. Nonetheless, negative UF or UF failure during the long dwell remains a significant clinical challenge, potentially leading to fluid overload and associated morbidities [8,10,11].

According to the International Society for Peritoneal Dialysis (ISPD), UF failure is defined as a net UF of less than 400 mL after a 4-hour dwell with glucose/dextrose 3.86%/4.25%, or less than 100 mL with glucose/dextrose 2.27%/2.5% [17]. Several factors contribute to UF variation under icodextrin, including patient membrane characteristics, hydrostatic and osmotic pressures, dialysate composition, and metabolic factors [8–10,18,19]. Lambie et al [8] closely examined these influences, emphasizing the importance of individualized management.

Another critical factor can be the intraperitoneal pressure (IPP), the pressure exerted within the abdominal cavity [20]. IPP is influenced by factors such as the volume of fluid in the peritoneal cavity, patient morphology, posture, and abdominal muscle tone [21,22]. IPP measurement, first described by Durand et al. [22–24] in the 1990s, is a simple and non-invasive procedure. It involves placing the patient in a supine position and estimating the pressure by measuring the height of the dialysate column in tubing connected to the catheter, using the mid-axillary line as the reference point [22–24]. For a patient in a supine position, IPP typically ranges between 8 and 18 cmH_2O for an infused peritoneal volume of 2 L [22,24].

Our study aimed to analyze the occurrence of negative daytime UF during icodextrin long dwell in patients undergoing APD, focusing specifically on this occurrence and identifying potential associated factors.

Materials and methods

Study population

This retrospective, observational, monocentric study was conducted in the Nephrology Department at the University Hospital of Caen in Normandy, France. It included all adult incident patients undergoing PD at our center from August 31, 2018, when systematic IPP measurement was initiated, until September 12, 2022. The study focused on patients who received APD treatment for at least six months after starting PD. Exclusion criteria comprised patients with an APD duration of less than 30 days or those who initiated APD more than six months after starting PD.

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Definition of variables

Patient characteristics included in the study were obtained from the French Language Peritoneal Dialysis Registry, RDPLF. The following variables were extracted: age, gender, initial nephropathy, modified Charlson index (mCCI), diabetic status, weight, and height.

Dialysis prescriptions were sourced from medical records and included the following variables: total dialysis volume, volume per cycle, volume of the last injection, total dialysis duration, dwell time per cycle, daytime dwell duration, number of nighttime cycles, use of hypertonic solution, use of icodextrin, and the percentage of icodextrin used, when applicable. Additionally, data on residual diuresis volume, IPP measurements, and the dates and results of the first peritoneal equilibration test (PET) and first clearance were collected.

Peritoneal dialysis outcomes were retrieved from the monitoring sheets for the first week of the second month of PD for patients included in the study, using Renalsoft® and Sharesource® software. The extracted variables included daytime, nighttime, and 24-hour UF, dwell time per cycle, daytime dwell duration, total per-cycle volume, and daytime dwell volumes. These variables were collected over the seven days leading up to the extraction and averaged, based on the assumption that this averaging would correct for variability within patients.

Events of interest

The primary outcome of interest was the occurrence of negative daytime UF, defined as an average daytime UF of less than 0 during the data extraction week. Patients included in the study were categorized based on the presence or absence of negative daytime UF (yes/no).

Explanatory variables

The primary exposure variable was IPP, measured in cm of H_2O with a 2 liter intraperitoneal dwell. At our center, IPP is routinely measured on the fourth day of patient training, prior to the initiation of PD. This measurement has been systematically performed since August 31, 2018, marking the start of patient inclusions in this study. The IPP measurement protocol adheres to the guidelines set forth by the ISPD [17].

Statistical Analysis

Linear variables were summarized using medians and interquartile ranges (IQR), while categorical variables were reported as frequencies and percentages. Patients were categorized based on the primary outcome, namely daytime UF, a binary qualitative variable with negative or positive classifications.

For further exploration of the association between negative daytime UF (the primary event of interest), IPP (the primary exposure variable), and other relevant exposure variables, graphical representations and univariate logistic regression analyses were performed. Each variable was analyzed separately in relation to the primary event, and the results were expressed as Odds Ratios (OR) with 95% confidence intervals (95% CI). Given the study's small sample size, confidence intervals were calculated using the bootstrap method.

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To adjust for potential confounders, a multivariate analysis was conducted, incorporating IPP and body mass index (BMI) due to its clinical relevance and correlation with IPP, along with any variables with a *p-value* < 0.20 in the univariate analysis. An analysis of variance (ANOVA) was used to assess the improvement in the logistic regression model after adjusting for covariates. Regarding the primary exposure variable, IPP, 20% of the data was missing, and a complete case analysis was performed. All statistical analyses were conducted using R version 4.0.2 - R Foundation for Statistical Computing, Vienna, Austria.

This study was approved by the Local Research Ethics Committee, CLER, of the University Hospital of Caen - ID 3793.

Results

Patient characteristics

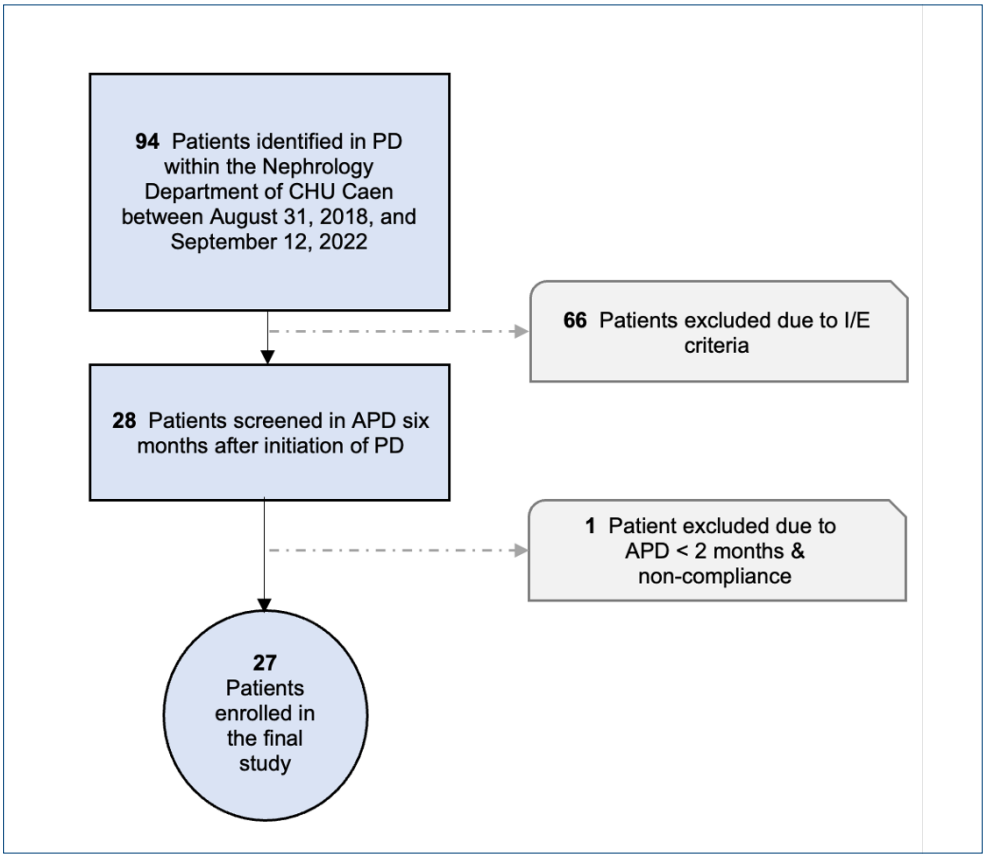

Figure 1. Study Design and Participant Overview

Between August 31, 2018, and September 12, 2022, a total of 94 patients initiated PD at our center, of whom 28 were treated with APD six months after PD initiation. One patient was excluded from the study due to non-compliance and a treatment duration of less than two months. Consequently, 27 patients were included in the final analysis *(Figure 1)*.

The clinical characteristics of the patients based on their daytime UF status (positive or negative)

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are presented in *Table I*. Both patient groups exhibited similar features. The sample comprised a majority of men, who accounted for 88.89% of the entire population. Patients had a median BMI indicating slight overweight (BMI > 25). The median BMI was slightly lower in patients with positive daytime UF (25.71 kg/m²) compared to those with negative daytime UF (26.93 kg/m²), with an overall median of 25.86 kg/m² for the entire population. In terms of comorbidities, the mCCI score showed a similar distribution between the two groups. It is worth noting that patients with negative daytime UF had slightly higher residual diuresis compared to those with positive daytime UF, with median values of 1650 mL and 1300 mL, respectively, although the difference between the two groups was not significant. Moreover, the BSA does not appear to differ significantly between patients with positive and negative daytime UF in this cohort, with a median BSA for patients with positive and negative daytime UF at 1.88 m².

Table I. Description of the clinical characteristics of the patients

		Patients with Positive Daytime UF (n = 17)	Patients with Negative Daytime UF (n = 10)	Total Population (n = 27)
Age at PD Initiation, Median (IQR), years		63,02 (48,3 - 79,1)	61,41 (46,43 - 67,7)	61,66 (46,45 - 72,41)
Gender, Male, n (%)		16 (94)	8 (80)	24 (88,89)
BMI, Median (IQR), kg/m²		25,71 (22,6 - 26,84)	26,93 (23,46 - 28,4)	25,86 (22,75 - 28,18)
BSA, Median (IQR), m²		1,88 (1,82 - 2,10)	1,88 (1,84 – 2,03)	1,88 (1,80 – 2,05)
mCCI Score, n (%)				
	2	7 (41,17)	3 (30)	10 (37,03)
	3	3 (17,65)	2 (20)	5 (18,52)
	4	3 (17,65)	2 (20)	5 (18,52)
	≥ 5	4 (23,53)	3 (30)	7 (25,93)
Diabetes, n (%)		5 (29,41)	2 (20)	7 (25,93)
Etiology of CKD, n (%)				
	Diabetic	3 (17,65)	1 (10)	4 (14,82)
	Interstitial Nephritis	2 (11,77)	2 (20)	4 (14,82)
	Glomerulonephritis	4 (23,53)	1 (10)	5 (18,52)
	PKD	3 (17,65)	3 (30)	6 (22,22)
	Uropathy	2 (11,77)	0 (0)	2 (7,41)
	Vascular	3 (17,65)	0 (0)	3 (11,11)
	Other	6 (35,29)	2 (20)	8 (29,63)
	Unknown	0 (0)	1 (10)	1 (3,70)
Residual Urine Output, Median (IQR), mL		1300 (1000 - 1650)	1650 (1175 - 1875)	1500 (1000 - 1700)

BMI: Body Mass Index; BSA : Body Surface Area ; CKD: Chronic Kidney Disease; ESKD: End-Stage Kidney Disease; IQR: Interquartile Range; mCCI: Modified Charlson Comorbidity Index; n: Total number of patients; PD: Peritoneal Dialysis; PKD: Polycystic Kidney Disease.

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PD characteristics

Prescriptions for PD patients and PD data are detailed in *Table II*. The median total UF was 210 ml/day for the entire population, 423 ml/day for patients with positive daytime UF, and -138.5 ml/day for patients with negative daytime UF. The total prescribed dialysate volume was similar between the two groups and for all patients, with a median of 7500 ml (IQR: 6500-8500). However, the actual administered volume varied: 6869 ml (IQR: 6260-7640) for the positive daytime UF group, 7663.5 ml (IQR: 6288.75-8154.5) for the negative daytime UF group, and a median of 7150 ml (IQR: 6227-7793) for the entire population. These results demonstrate a certain variation in the effective administration of the prescribed volume. Regarding the volume of the last injection, there was a median of 1500 ml (IQR: 1500-2000) for the positive daytime UF group, 2000 ml (IQR: 1750-2000) for the negative daytime UF group, and a median of 1800 ml (IQR: 1500-2000) for the entire population. However, the actual administered volume of the last injection was notably similar in both groups.

Table II. The prescription and management of peritoneal dialysis

		Patients with Positive Daytime UF (n = 17)	Patients with Negative Daytime UF (n = 10)	Total Population (n = 27)	*p-value* (α = 0,05)
Total Dialysate Volume, Median (IQR), mL					
	Prescribed	7500 (6500 - 8500)	8250 (7000 - 9000)	7500 (7000 - 9000)	0,2335
	Average	6869 (6260 - 7640)	7663,5 (6288,75 - 8154,5)	7150 (6227 - 7793)	0,4143
Last Infusion Volume, Median (IQR), mL					
	Prescribed	1500 (1500 - 2000)	2000 (1750 - 2000)	1800 (1500 - 2000)	0,2285
	Average	1496 (975 - 1835,5)	1532,5 (1007,75-1919,75)	1499 (996 - 1922)	0,7234
Daytime Dwell Time, Median (IQR), H					
	Prescribed	16 (15,5 - 16)	16 (16 - 16)	16 (15,97 - 16)	0,05144
	Average	15,73 (15,03 - 15,92)	15,84 (15,8 - 16,31)	15,8 (15,58 - 15,92)	0,1318
Number of Cycles, n (%)					0,8765
	2	3(17,65)	1 (10)	4 (14,81)	
	3	5 (29,41)	3 (30)	8 (29,63)	
	4	5 (29,41)	5 (50)	10 (37)	
	5	3 (17,65)	1 (10)	4 (14,82)	
	6	1 (5,88)	0 (0)	1 (3,7)	
Use of Hypertonic Solution, n (%)		4 (23,53)	1 (10)	5 (18,52)	0,621
Kt/V, Median (IQR)		2,23(1,67 - 2,63)	2,12 (1,7 - 2,29)	2,14 (1,7 - 2,47)	0,6918
Total Clearance, Median (IQR), L/week/1.73m²		94,65 (77,52 - 107,78)	92,44 (85,07 - 98,61)	92,44 (82,51 - 103,55)	1
IPP, Median (IQR), cmH_2O		13 (10,25 - 14,75)	14 (12-15)	14 (12 - 15)	0,3686
Fluctuation, Median (IQR), %		0,8 (0,75 - 0,8)	0,78 (0,7 - 0,8)	0,8 (0,7 - 0,8)	0,5359
Total 24-Hour UF, Median (IQR), mL/day		423 (293 - 532)	-138,5 ([-184,25] - [-90,5])	210 ([-95] - 469,5)	reference
Day-time UF, Median (IQR), mL/day		237 (188 - 406)	-139 ([-331,35] - [-109,5])	104 ([-115] - 361)	
Night-time UF, Median (IQR), mL/day		244 (126 - 285)	-132,5 ([-268,25] - [-68])	-10 ([-132,5] - 242,5)	

IPP: Intraperitoneal Pressure; IQR: Interquartile Range; n: Total number of patients; UF: Ultrafiltration.

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The prescribed daytime dwell time was similar between the groups, with a median of 16 hours for the sample (IQR: 15.97-16). Median values for the mean daytime dwell time and IQR indicated that the prescribed duration was generally maintained within a narrow range, at 15.8 (IQR: 15.58-15.92), demonstrating consistency in managing dwell time for PD patients. Hypertonic solution use was an option for 18.52% of patients, with a slight difference between the groups: 23.53% for the positive UF group and 10% for the negative UF group. Median values for Kt/V and total clearance were very similar between the groups. The IPP measured at the start of PD was 14 (12-15) cmH_2O for all patients, 13 (10.25 - 14.75) cmH_2O for patients with positive daytime UF, and 14 (12-15) cmH_2O for those with negative daytime UF. Finally, the median values of the fluctuating variable were consistent across the groups, averaging around 80%.

Association between exposure variables and negative daytime UF

⬇ *Table III. Univariate logistic regression analysis examining the association between negative daytime ultrafiltration (UF) events and each explanatory variable*

	OR (95% IC)	*p value* (α = 0,05)
Age at the initiation of PD, increased by 10 years	1,02 (0,89 - 1,11)	0,93
Chronic Kidney Disease		
Diabetes	référence	
Glomerulonephritis	0,50 (0,02 - 8,51)	0,64
Interstitial	0,50 (0,02 - 8,51)	0,64
PKD	7,50 (0,56 - 2,18)	0,16
Other	0,21 (0,01 - 3,09)	0,27
mCCI, increased by one unit	0,98 (0,86 - 1,10)	0,69
Residual diuresis, increased by 100 mL	1,17 (0,83 - 1,67)	0,41
BMI	0,98 (0,94 - 1,03)	0,29
IPP, increased by 1 cmH2O	1,05 (0,99 - 1,10)	0,09
PET, type of membrane		
High	reference	
Medium-High	1,12 (0,70 - 1,84)	0,63
Kt/V	1,07 (0,71 - 1,43)	0,68
Volume of last injection, L	0,84 (0,67 - 1,02)	0,12
Daytime stasis time, H	0,96 (0,70 - 1,26)	0,74
Fluctuation, increased by 10%	1,85 (0,37 - 2,74)	0,28

BMI: Body Mass Index; CI: Confidence Interval ; CKD: Chronic Kidney Disease; mCCI: Modified Charlson Co-morbidity Index; IPP: Intraperitoneal Pressure; PD: Peritoneal Dialysis; PET: Peritoneal Equilibration Test; PKD: Polycystic Kidney Disease; OR: Odds Ratio; UF: Ultrafiltration.

The association between the «negative daytime UF» event (binary categorical variable) and the various exposure variables was assessed using logistic regression analyses. The results of the univariate logistic regression analysis are presented in *Table III*. Each explanatory variable was evaluated separately in relation to the negative daytime UF event. None of the examined variables demonstrated a statistically significant association with the negative daytime UF event, although

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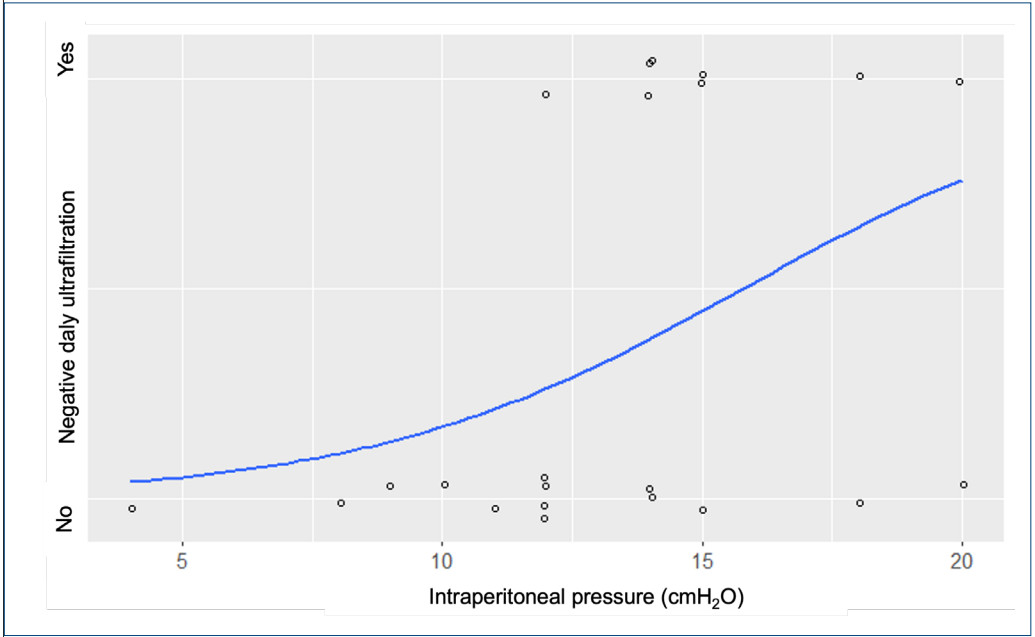
some of them showed interesting trends. Specifically, the IPP *(Figure 2)*, the volume of the last injection, and the BMI appear to be the most relevant within our analysis. *Figure 2* displays the association between negative daytime UF and PIP values, showing the distribution in an almost sigmoidal curve pattern.



The x-axis represents intraperitoneal pressure (IPP) values, while the y-axis categorizes ultrafiltration (UF) status: the bottom section indicates positive UF (no negative ultrafiltration), and the top section indicates negative UF. Each dot represents an individual patient's IPP value, positioned according to their UF status. The blue line illustrates the relationship between IPP and UF status, following an approximately sigmoidal pattern

⬆ *Figure 2. Relationship between intra peritoneal pressure and negative UF*

Additionally, to minimize the risk of confounding, a multivariate logistic regression was conducted. The variables included in the model were IPP, our primary exposure variable, as well as BMI, a clinically relevant variable correlated with IPP, and variables with a *p-value* less than 0.20, notably the volume of the last injection. The results of the multivariate analysis are presented in *Table 4*. In the multivariate analysis, none of the variables were significantly associated with the negative daytime UF event. To test the model's robustness, an ANOVA analysis was performed, indicating that IPP was the only variable that improved the model's quality *(p-value* at 0.05*)*.

⬇ *Table IV. Adjusted multivariate logistic regression of each explanatory variable with the event of negative daily ultrafiltration*

	OR (95% IC)	*p value* (α = 0,05)
BMI	0,97 (0,91 - 1,03)	0,50
IPP, cm H_2O	1,06 (0,96 - 1,13)	0,54
Volume of last injection, L	0,97 (0,74 - 1,32)	0,53

BMI: Body Mass Index; IPP: Intraperitoneal Pressure

Discussion

The results of our analysis on UF volume during the long dwell with icodextrin in APD highlight interesting dynamics. Notably, IPP emerges as the primary determinant of interest. However, it is crucial to acknowledge that our small cohort size likely limited the statistical power of this study,

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restricting our ability to capture the complexity of the interactions fully.
The clinical impact of IPP variation is still poorly documented in the literature, with many existing studies being constrained by small sample sizes and methodological limitations. For instance, Imholz et al. [18] demonstrated that increases in IPP led to a reduction in net UF, primarily due to enhanced lymphatic absorption. Similarly, Díaz et al. [25] reported that IPP influences PD efficiency by decreasing UF and solute clearance. Moreover, Durand et al. [23,24] found that even a modest increase of 1 cmH_2O in IPP could decrease total UF by 70 mL after two hours, primarily due to increased lymphatic reabsorption.

In addition, in 2009, Lambie et al. highlighted that intraperitoneal and extraperitoneal hydrostatic pressures, as well as osmotic pressures, were key factors influencing the direction and quantity of UF. Specifically, high intraperitoneal hydrostatic pressure, and thus high IPP, favors fluid reabsorption that can result in negative UF, while high plasma colloidal osmotic pressure favors UF [8].

Moreover, our findings, while not statistically significant, suggest a possible dynamic between BMI and daytime UF. Several studies have demonstrated a correlation between BMI and IPP, with Castellanos et al. and Dejardin et al. [20,21] both observing that higher BMI correlates with elevated IPP. This suggests that patients with higher BMI may be more likely to experience increased IPP, potentially contributing to negative UF. Further, larger studies should tend to investigate the potential interaction between BMI and IPP, and its impact on UF volumes.

We also observed a potential link between the prescribed volume of the last injection and daytime UF. Specifically, higher prescribed volumes appeared to be associated with more negative daytime UF, although the results were not statistically significant. This association may be mediated by IPP, as an increase in prescribed volume could elevate IPP, thus influencing UF. Current guidelines recommend individualized PD prescriptions, focusing on fluid balance, nutritional and metabolic aspects, and small molecule clearance [26]. While the ISPD does not recommend routine IPP measurement, we believe it could serve as a valuable tool for optimizing PD prescriptions [24–26]. Measuring IPP could assist in adjusting the amount of fluid used during PD to prevent complications. Regular monitoring of IPP may help identify at-risk patients and guide clinical management. In cases of UF failure or fluid overload, IPP measurement can be especially useful for diagnosing UF losses, assessing the patient's tolerance to intraperitoneal fluid, and optimizing treatment strategies. At the University Hospital of Caen, IPP is routinely measured at the onset of PD. In cases of elevated IPP, PD prescriptions are reassessed by reducing the infused volumes. This approach helps ensure that IPP levels are appropriately managed, potentially improving UF outcomes.

Another compelling finding in our analysis was that, while the results were not statistically significant among diabetic patients, five out of seven achieved positive UF. Previously, Ahmad et al. [13] conducted a retrospective study comparing UF variations in 17 diabetic and 23 non-diabetic patients undergoing APD. Their results suggest that icodextrin may be more effective for UF in diabetic patients, although the underlying mechanisms remain unclear.

In our sample, we found that patients with negative daytime UF exhibited a higher level of residual renal function. This observation leads us to consider whether negative ultrafiltration might be linked to fluid reabsorption, which could contribute to a state of relative hypervolemia and, in turn, explain the increased urine volume observed in these patients.

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Finally, we observed that the use of hypertonic solutions during night-time exchanges was lower in the negative daytime UF group. Hypertonic solutions are commonly used to enhance UF by increasing the osmotic gradient. Additionally, it was noted that residual diuresis was greater in this group. We hypothesize that patients with negative daytime UF may have more preserved renal function, better volume control, and consequently less need for hypertonic solutions to achieve UF.

Several limitations must be considered when interpreting the results of this study. The primary limitation is the small sample size, which reduces the statistical power of the analysis and may impair our ability to detect significant differences between the groups. This highlights the necessity for larger, more comprehensive studies to confirm and refine our findings. We also assumed that averaging the daily UF volume over a week would help reduce variability within patients. UF calculations were performed using Sharesource®. Furthermore, this study utilized a retrospective observational design, which inherently restricted our ability to establish causal relationships between the variables. Despite our efforts to control for known confounders, there may still be unmeasured variables that could have introduced bias into our results. It is essential to recognize this observational nature when interpreting our findings, as we cannot definitively infer causality. Additionally, the study was conducted at a single center, which may limit the generalizability of our conclusions. The characteristics of our sample and the specific institutional environment might not accurately represent broader patient populations or clinical settings. Therefore, caution should be exercised when applying our results to other contexts, and further replication of these findings in diverse populations and settings is necessary. Measuring peritoneal pressure on day four may also lead to overestimated values, as the abdominal wall may not fully adapt to the presence of fluid, particularly in cases involving significant intraperitoneal volume. Lastly, while we have attempted to account for various confounding factors, there remains the possibility that unmeasured variables—including detailed medical histories, individual health behaviors, and sociodemographic factors—could have influenced the outcomes. These factors were not included in our analysis, and their potential impact should be considered when interpreting our findings.

Conclusion

In conclusion, this retrospective, single-center observational study investigated the occurrence of negative daytime UF in APD using icodextrin and examined potential factors influencing this outcome. Although our findings were not statistically significant, likely due to the limited sample size, they suggest a possible association between increased IPP and negative daytime UF. While routine measurement of IPP is not currently recommended in clinical practice, our results underscore its potential importance in optimizing treatment. We advise centers that do not routinely measure IPP to consider evaluating it in cases of negative daytime UF. This will help ensure that IPP levels are not excessively elevated, and adjusting peritoneal dialysis prescriptions by reducing infused volumes in such instances may enhance patient outcomes. Given the limitations of our study, particularly the small cohort size, further research is necessary to better understand the clinical implications of IPP and its role in UF during APD.

Authors' Contributions

Srouji T.: Contributed to the conceptualization of the study, performed statistical analysis, and wrote the manuscript.

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Boyer A.: Contributed to the conceptualization of the study, performed statistical analysis, and revised the manuscript.
Lanot A., Béchade C., Lobbedez T.: Contributed to the design of the study.

Ethical Approval

This study was approved by the Local Research Ethics Committee, CLER, of the University Hospital of Caen (ID 3793).

Patient Consent

This retrospective observational study is based on data from patients followed at the University Hospital of Caen. In accordance with current regulations, individual patient consent is not required. Approval from the Local Research Ethics Committee (CLER) is sufficient.

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Conflicts of Interest

The authors have none to declare.

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