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Barriers in adequacy goals in peritoneal dialysis: evaluation of a cohort with negative selection bias

(Barrières dans les objectifs d'adéquation en dialyse péritonéale : évaluation d'une cohorte avec biais de sélection négatif)

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Summary

Our study aimed to evaluate PD patients tracing a sociodemographic profile and jointly evaluating the clinical and laboratory parameters of dialysis adequacy, as well as outcomes. A prospective cohort study in a dialysis unit of the Juiz de Fora Federal University Hospital in Brazil between July 2021 and July 2022. The sociodemographic, clinical, laboratorial data and adherence were assessed. The Short Assessment of Health Literacy for Portuguese-Speaking Adults score, a score of perception of social support, a tool for the evaluation of QoL (SF-12), and Malnutrition Inflammation Score (MIS) were performed. The primary outcomes were death and QoL, whereas technique failure and hospitalization were secondary. Fifty-six patients in automated peritoneal dialysis modality were evaluated (73.2% prevalent and 26.8% incident). The majority were women (61.2 ± 13.9 years old), white, illiterate and with low income. All patients were hypertensive, one-third had diabetes mellitus (DM) and 76.8% were compliant. The definition of goals were the patient stayed into the normal range within 80% of the follow time. The adequacy goals of blood pressure (30.4%) and phosphorus (28.6%) were the most difficult to achieve. Among the primary outcomes, physical component of the SF-12 was negatively associated with higher MIS and the mental component of the SF-12 was negatively correlated with higher age. There was no significant difference of death as outcome. The factors that were associated with the achievement of goals were age, previous nephrological follow-up, dementia, DM and adherence.

Keywords: peritoneal dialysis; chronic kidney failure; kidney replacement therapy; barriers to access to healthcare; azotemia.

Résumé

Notre étude visait à évaluer les patients sous dialyse péritonéale (DP) en traçant un profil sociodémographique et en évaluant conjointement les paramètres cliniques et biologiques de l'adéquation de la dialyse, ainsi que les résultats. Il s'agit d'une étude de cohorte prospective menée dans une unité de dialyse de l'Hôpital Universitaire Fédéral de Juiz de Fora au Brésil, entre juillet 2021 et juillet 2022. Les données sociodémographiques, cliniques, biologiques et l'adhésion à la technique ont été évaluées. Le "Short Assessment of Health Literacy for Portuguese-Speaking Adults score", un score de perception du soutien social, un outil d'évaluation de la qualité de vie (SF-12) et le score de malnutrition-inflammation ont été réalisés. Les résultats primaires étaient le décès et la qualité de vie, tandis que l'échec de la technique et l'hospitalisation étaient les critères secondaires. Cinquante-six patients sous dialyse péritonéale automatisée ont été évalués (73,2 % prévalents et 26,8 % incidents). La majorité étaient des femmes (61,2 ± 13,9 ans), blanches, analphabètes et à faible revenu. Tous les patients étaient hypertendus, un tiers avait un diabète sucré et 76,8 % étaient compliant à leur traitement. Les objectifs d'adéquation de la pression artérielle (30,4 %) et du phosphore (28,6 %) étaient les plus difficiles à atteindre. Parmi les résultats primaires, la composante physique du SF-12 était négativement associée à un score de malnutrition-inflammation plus élevé et le composante mentale était négativement corrélée avec l'âge avancé. Les facteurs associés à l'atteinte des objectifs étaient l'âge, le suivi néphrologique antérieur, la démence, l'existance d'un diabère et la compliance.

Mots-clés : dialyse péritonéale,insuffisance rénale chronique, thérapie de substitution renale, barrières à l'accès aux soins de santé, azotémie

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INTRODUCTION

Chronic kidney disease (CKD) is a serious public health problem worldwide, with a prevalence of 10%. Approximately 0.1% of these patients require kidney replacement therapy (KRT). Estimates from the International Society of Nephrology point to alarming numbers in 2030, when approximately 14.5 million people will need KRT, but only approximately 5.4 million will have access to treatment due to socioeconomic, cultural and political factors [1].

Among the KRT modalities, peritoneal dialysis (PD) represents 9% of all KRT worldwide, despite its known advantages over hemodialysis (HD) and the difficulties in performing kidney transplants on a large scale [2]. In 2022, data from the Brazilian Society of Nephrology revealed the underutilization of the method, with only 4.7% of patients on PD [3]. In addition, the lack of knowledge, adequate training and interest in the method, and the low reimbursement for dialysis clinics, PD modality has been delegated to patients for whom other modalities are not a good fit. This negative selection bias shows a population reaching PD with more comorbidities, without residual kidney function (RKF) and often previously receiving other forms of KRT [4,5].

There are large disparities in access to PD worldwide [6], but the negative selection bias makes the suitability of the method a major challenge for health professionals and should be addressed on multiple fronts. In this context, in 2020, the ISPD published new guidelines for adequacy in PD that focused on individual needs through a holistic approach to the detriment of strict control of uremic solutes. This patient-centered approach aims to ensure physical, mental and social well-being with a focus on better quality of life (QoL) and symptom control [7]. This individualized approach is also focused on solute clearance, which might be complex and challenging in these patients, negatively selected for PD as a rescue therapy [7,8]. The definitions of goals were the patient stayed into the normal range of the clinical and laboratorial parameters within 80% of the following time.

Our study aimed to evaluate PD patients treated at a Brazilian University Hospital by tracing a sociodemographic profile of the population and jointly evaluating the clinical and laboratory parameters of dialysis adequacy, as well as outcomes of interest in the method. Thus, we aim to better understand who our patients are and identify potential barriers to adapting to the method, enabling us to address challenges in providing better care and support the dissemination of the therapy.

MATERIAL AND METHODS

Setting, period and inclusion criteria

A prospective cohort study of prevalent and incident PD patients in a dialysis unit of Federal University Hospital in Brazil between July 2021 and July 2022.

The inclusion criteria were age ≥18 years and a signed informed consent form (ICF)

The exclusion criteria were no signed ICF or age below 18 years (Figure 1).

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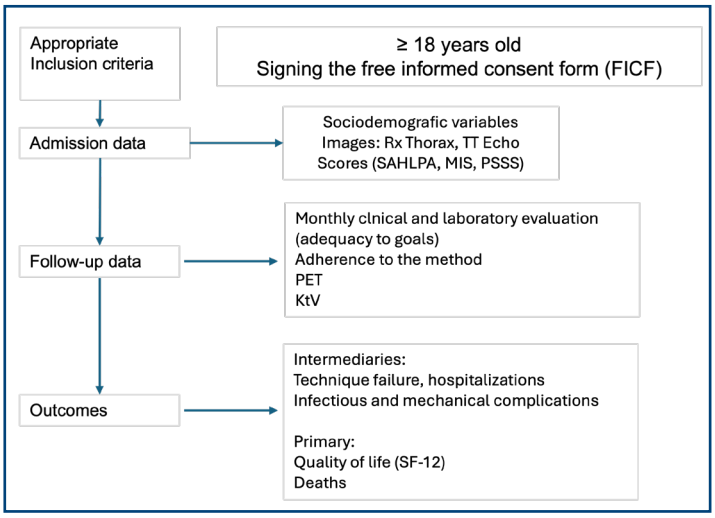
Data Sources

We evaluated the sociodemographic and clinical data. Adherence to the technique was assessed by means of attendance at medical appointments, ultrafiltration (UF) records and body weight in the monthly dialysis reports, as well as correct information on the number of dialysis bags checked by nurses. To be considered adherent, the patient should be within the proposed goals for at least 80% of the follow up-time.



⬆*Figure 1: Data collection procedure*
Caption: SAHLPA-Short assessment of health literacy for Portuguese-speaking adults score; MIS: Malnutrition and inflammation score; PSSS: Perceived social support score; SF12: Short Form-12 Score; KtV: Kinetic urea removal index; PET: Peritoneal equilibration test; TT Echo: Transthoracic echocardiogram

Retrospective data such as previous KRT were considered regarding their presence and duration, as well as previous follow-up with a nephrologist (period ≥ six months). The following clinical data were monthly recorded: body mass index (BMI) [9], systemic arterial pressure (SAP), residual diuresis and presence of edema.

Laboratory tests were also recorded according to the National Health Surveillance Agency (ANVISA) protocol [10]. The reference values considered were fasting glucose (< 110 mg/dl), hemoglobin (Hb) (> 10 g/dl), transferrin saturation index (TSI) (> 20%), ferritin (100-600 ng/dl), calcium (8.5-10.5 mg/dl), phosphorus (< 5.5 mg/dl), parathyroid hormone (PTH) (150-600 pg/ml), alkaline phosphatase (ALP) (65-300 U/L), potassium (< 5.5 mEq/L), albumin (> 3.5 g/dl) and weekly Kt/V (> 1.7). Thus, we evaluated a total of 13 adequacy goals. An annual peritoneal equilibrium test (PET) [11] and an evaluation of urea kinetic adequacy f (Kt/V) [12] were performed. Adequacy to the clinical and laboratory goals follow the same definitions to the technique adherence that is the patient should be within the proposed goals for at the least 80% of the follow up-time.

The patients also underwent the application of scores for the analysis of health literacy by the Short Assessment of Health Literacy for Portuguese-speaking adults score (SAHLPA-18) [13], a Scale of Perception of Social Support (SPSS) [14] , the assessment of nutritional status by a Malnutrition Inflammation Score (MIS) [15] and a tool for the evaluation of QoL (SF-12) [16].

The main drugs used were recorded. The following complications of the method were evaluated: exit site infection (ESI) and tunnel infections, peritoneal dialysis associated peritonitis (PD peritonitis) and mechanical complications (hernias, leakages, fistulas and catheter translocations) according to the criteria of the International Society of Peritoneal Dialysis (ISPD) [17].

Outcomes

Death and QoL were defined as primary, whereas PD discontinuation and hospitalization were defined as secondary.

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Statistical analysis

We performed a descriptive analysis and subsequently, we compared incidents (patients who started PD after the first day of July 2021) versus prevalents (patients who were in PD before the first day of July 2021) with respect to sociodemographic, clinical, laboratory, scores, complications and outcomes. This same analysis was performed between patients in and out goals in order to verify the association of these variables with goals.

We consider as goals the achievement of a total of thirteen clinical and laboratory parameters of dialysis adequacy (BP, edema, Hb, TSI, ferritin, blood glucose, calcium, phosphorus, ALP, PTH, potassium, albumin and Kt/V).

The secondary and primary outcomes were correlated with the 13 established adequacy goals to verify which factors interfered with them. Finally, we used a linear regression model to evaluate the variables associated with QoL (physical and mental components) and logistic regression to evaluate outcomes: hospitalization, PD discontinuation and death; these models were adjusted for confounders with biological plausibility and/or statistical significance. We used Statistical Package for the Social Sciences 25.0 Chicago, Illinois, and adopted a CI of 95%.

Ethical considerations and conduct of study

The study was approved by the Ethics and Research Board of the University Hospital of the Federal University of Juiz de Fora under no 5.001.893. All patients signed ICF, STROBE rules and the Declaration of Helsinki were followed.

RESULTS

Sociodemographic and Clinical Data

All the 56 patients evaluated were in automated peritoneal dialysis (APD) because no patients choose the continuous ambulatory peritoneal dialysis (CAPD) modality. Furthermore, all of them using glucose-based solutions (icodextrin is not available in the public health system in Brazil).

In total, 73.2% (41 patients) being prevalent and 26.8% (15 patients) incident patients. These patients were on Home Choice APD, but not Claria system™ (Baxter) with the Sharesource™ (Baxter) remote patient management (RPM). The prescriptions were made by the attending nephrologist and adjusted according to the clinical and laboratory conditions of the patient. Twenty-seven percent of the patients were on incremental dialysis during the study (which means less than seven days a week performing PD).

The majority were women, with a mean age of 61.2 ± 13.9 years, white, illiterate and with low income (*Table I*). Only two patients did not have caregivers (*Table Ia-Ib*).

Among the underlying CKD, the main cause was undetermined. All patients were hypertensive and one-third diabetic (*Table Ia-Ib*). A total of 76.8% of the patients were considered adherent to the method. Most patients had previous nephrological follow-up (*Table I*). Of the prevalent patients, 22% had already presented at least one episode of peritonitis, and regarding previous KRT, 67.9% had undergone HD for 23 ±4 months on average.

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Table Ia - Socio-demographic data of the prevalent and incident patients

Variable	Total (%) (n = 56)	Prevalent (%) (n = 41)	Incidents (%) (n = 15)	p-value
Age (years) (mean; ±)	26-86 61,2 ± 13.9	26-86 62 ± 14.2	36-84 57.5 ± 12.5	0.09
Sex				
Male	27 (48.2)	18 (43.9)	9 (60)	0.37
Female	29 (51.8)	23 (56.1)	6 (40)	
Education				
Illiterate	23 (41)	19 (46.3)	4 (26.6)	0.37
Fundamental	5 (8.9)	2 (4.9)	3 (20)	
Medium	19 (33.9)	13 (31.8)	6 (40)	
Superior	9 (16.1)	7 (17)	2 (13.3)	
Marital status				
Married	37 (66.1)	27 (65.8)	10 (66.6)	0.60
Not married	19 (33.9)	14 (34.2)	5 (33.4)	
Color				
White	35 (62.5)	26 (63.4)	9 (60)	0.048
Black	7 (12.5)	7 (17.1)	0 (0)	
Brown	14 (25)	8 (19.5)	6 (40)	
Sanitation				
Yes		56 (100)	15 (100)	-
No		0 (0)	0 (0)	
Monthly income				
Up to 1 MW	6 (10.7)	5 (12.2)	1 (6.6)	0.47
1-2 MW	31 (55.4)	23 (56.1)	8 (53.3)	
2-5 MW	10 (17.9)	7 (17.1)	3 (20)	
Above 5 MW	9 (16.1)	6 (14.6)	3 (20)	
Caregiver in PD				
Yes	54 (96.4)	39 (95.1)	15 (100)	0.53
No	2 (3.6)	2 (4.9)	0 (0)	
Indication in PD				
Personal option	40 (71.4)	30 (73.2)	10 (66.6)	0.74
Medical recommendation	16 (28.6)	11 (26.8)	5 (33.4)	
Residence				
Juiz de Fora	32 (57.1)	25 (61)	7 (46.6)	0.37
Other cities	24 (42.9)	16 (39)	8 (53.3)	
Self-sufficiency in PD				
No	31 (55.4)	22 (53.6)	9 (60)	0.76
Yes	25 (44.6)	19 (46.3)	6 (40)	
Occupation				
Retiree	46 (82.1)	36 (87.8)	10 (66.6)	0.21
None	4 (7.1)	2 (4.9)	2 (13.3)	
Assets	6 (10.7)	3 (7.3)	3 (20)	

Caption: % (percentage); n (number in sample); ± (standard deviation); PD (peritoneal dialysis); MW (minimum wage).

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Table Ib - Socio-demographic data of the prevalent and incident patients

Variable	Total (%) (n = 56)	Prevalent (%) (n = 41)	Incidents (%) (n = 15)	p-value
Physical Disability				
Yes	8 (14.3)	7 (17)	1 (6.6)	0.42
No	48 (85.7)	34 (83)	14 (93.4)	
Etiology of CKD				
SAH	8 (14.3)	6 (14.6)	2 (13.3)	0.44
Diabetes	12 (21.4)	10 (24.4)	2 (13.3)	
ADPKD	8 (14.3)	7 (17.1)	1 (6.6)	
Glomerulonephritis	12 (21.4)	8 (19.5)	4 (26.6)	
Indeterminate	15 (26.8)	10 (24.4)	5 (33.4)	
Obstructive	1 (1.8)	0 (0)	1 (6.6)	
Comorbidities				
SAH	56 (100)	41 (100)	15 (100)	-
Diabetes	17 (30.4)	14 (34)	3 (20)	0.51
Obesity	11 (19.6)	7 (17)	4 (26.6)	0.46
CHF	13 (23.2)	10 (24.4)	3 (20)	0.51
CAD	13 (23.2)	11 (26.8)	1 (10)	0.47
PVD	3 (5.4)	1 (2.4)	2 (13.3)	0.17
Collagenosis	2 (3.6)	1 (2.4)	1 (6.6)	0.46
Dementia	8 (14.3)	6 (14.6)	2 (13.3)	0.63
Neoplasm	6 (10.7)	4 (9.8)	2 (13.3)	0.65
COPD	4 (7.1)	3 (7.3)	1 (6.6)	0.71
Hepatitis C	1 (1.8)	1 (2.5)	0 (0)	0.73
Liver cirrhosis	0 (0)	0 (0)	0 (0)	-
HIV	0 (0)	0 (0)	0 (0)	-
Adherence to PD				
Yes	43 (76.8)	34 (83)	9 (60)	0.51
No	13 (23.2)	7 (17)	6 (40)	
BMI				
Underweight	8 (14.5)	4 (9.8)	4 (28.6)	0.28
Ideal weight	28 (50.9)	23 (56.1)	5 (35.7)	
Overweight	9 (16.4)	6 (14.6)	3 (21.4)	
Obese	10 (18.2)	8 (19.5)	2 (14.3)	
Diuresis (mL)				
Median (p25-p75)	814 (300-1282.28)	568 (237.63-1030)	1.285.71 (820-1533.33)	0.01

Caption: % (percentage); n (number in sample); ± (standard deviation); PD (peritoneal dialysis); MW (minimum wage); CKD (chronic kidney disease); SAH (systemic arterial hypertension); ADPKD (autosomal dominant polycystic kidney disease); CHF (congestive heart failure); CAD (coronary arterial disease); COPD (Chronic Obstructive Pulmonary Disease), PVD (peripheral vascular disease); HIV (acquired immunodeficiency virus); PD (peritoneal dialysis); BMI (body mass index); mL (milliliter); p25-p75 (25th percentile and 75th percentile).

The SAHLPA [13] revealed low health literacy. Regarding the MIS [16], the values were found to be low (*Figure 2.1*). According to the SF-12 [15] scores, the total average scores for the physical component and the mental component were low (*Figure 2.2*). The SPSS [14] showed an adequate total mean in its practical and emotional components (*Figure 2.3*). According to the BMI [9], 50.9% were at their ideal weight (*Table 1*).

Drugs in use

Among the main drugs used, angiotensin converter enzyme inhibitors (ACEIs) or angiotensin receptor blockers (ARBs) and erythropoietin (Epo) were the most used (*Figure 2.4*).

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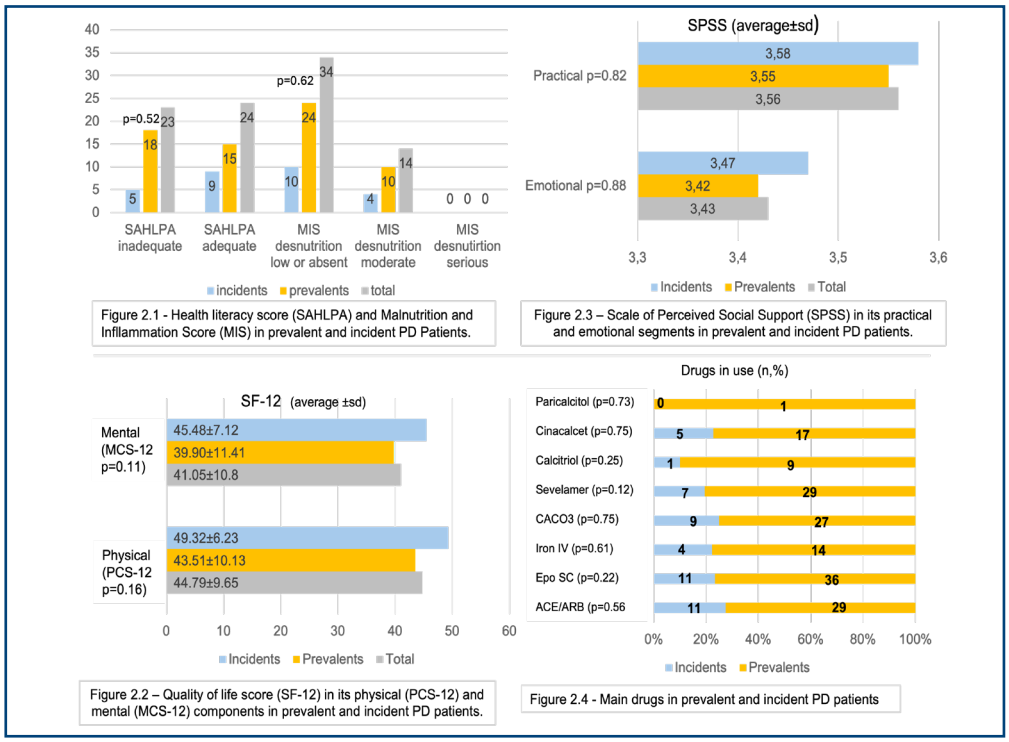

Figure 2.1 - Health literacy score (SAHLPA) and Malnutrition and Inflammation Score (MIS) in prevalent and incident PD Patients.

Figure 2.3 – Scale of Perceived Social Support (SPSS) in its practical and emotional segments in prevalent and incident PD patients.

Figure 2.2 – Quality of life score (SF-12) in its physical (PCS-12) and mental (MCS-12) components in prevalent and incident PD patients.

Figure 2.4 - Main drugs in prevalent and incident PD patients

⬆*Figure 2.1 – Health Literacy Score (SAHLPA) and Malnutrition and Inflammation Score (MIS) in prevalent and incident PD patients. Figure 2.2 – Quality of Life Score (SF-12) in its physical and Mental (MCS-12) components in prevalent and incident PD patients. Figure 2.3 – Scale of Perceived Social Support (SPSS) in its practical and emotional segments in prevalent and incident PD patients. Figure 2.4 – Main Drugs used in prevalent and incident patients.*

Membrane Characteristics and Adequacy Goals

Among the 73.2% patients who underwent PET [11], 9.7% had slow peritoneal solute transfer rate (PSTR), 53.6% had medium-low PSTR, 34.1% had medium-fast PSTR and only 4.1% had fast PSTR. When Kt/V [12] was performed, the overall mean was 1.89 ± 0.61.

Among the patients who underwent echocardiography (75% of the sample), 81% had some degree of left ventricular hypertrophy, which was considered moderate or severe in 40.5%. On radiological analysis, a pattern of pulmonary venocapillary congestion was observed in one-third of the sample, with a statistically significant difference between incidents (7.7%) and prevalent cases (41.4%) (p = 0.04).

The median diuresis of the study population was 814 ml and was higher among incident patients (*Table 1*). Nine patients in the study were anuric, eight of whom were prevalent cases and one of whom was an incident case. This incident patient underwent HD previously.

Regarding the adequacy goals in PD we noted that, in general, the goals of blood pressure (BP) (30.4%) and phosphorus (28.6%) were the most difficult to achieve. On the other hand, the goals most commonly achieved were potassium (62.5%), albumin (60.7%), KtV [12] (61.5%) and the absence of edema (60.7%). It's important to note that 100% of the patients had a diagnosis of SAH but 69.6% remained out of the goals during the study even without edema. When evaluating the hematological parameters, Hb (42.9%), TSIs (39.3%) and ferritin (35.7%), we observed a minority of patients within the goals. When bone mineral disorder (BMD-CKD) was assessed,

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calcium was found to be a low therapeutic target (37.5%), while PTH (51%) and ALP (50%) were the best targets. In the comparison between prevalent and incident patients, none of these variables showed statistical significance (figure 3).

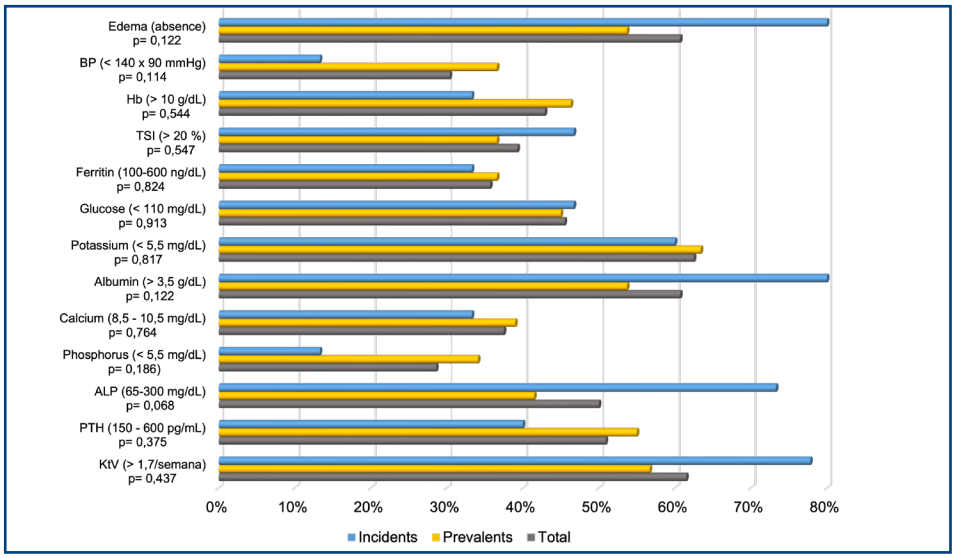

Figure 3: Adequacy goals in PD

Caption: BP- blood pressure; Edema- presence of "Locker" in the lower limbs; Hb-hemoglobin; TSI- transferrin saturation index; Ca-calcium; P-phosphorus; ALP-alkaline phosphatase; PTH- parathyroid hormone; K-potassium; KtV- kinetic urea removal index; MIS- malnutrition and inflammation score; SF-12- Short Form-12 quality of life score; SPSS- Scale of Perceived Social Support; ACEIs/ARBs- angiotensin-converting enzyme inhibitors/angiotensin II receptor blockers.

Analysis of the factors that interfered with the goals, as shown in Figure 4, we found that for the BP goal, advanced age (p=0.03), lower adherence to the technique (p = 0.005) dementia (p=0.04), the presence of peritonitis (p=0.05) and a worst mental component of the SF-12 [15] (p=0.048) were associated with worst goals (*Figure 4*).

Among the hematological parameters, Hb was more on the target among those with previous nephrological follow-up (p = 0.01), lower MIS [16] (p = 0.002) and a greatest physical component of the SF-12 [15] (p = 0.006). The best ferritin levels and the use of ACEIs/ARBs (p = 0.03) were associated with a lower prevalence of dementia (p = 0.04). In turn, TSIs were related only to hospitalizations, and conversely, a higher level of TSIs was associated with a higher rate of hospitalizations (p = 0.05). This association is not easily explained and is possible because of the small sample (*Figure 4*).

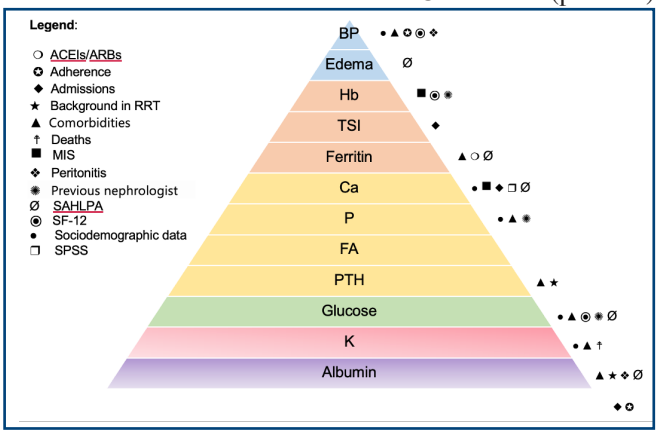

Figure 4: Caption: BP- blood pressure; Edema- lower limbs pitting edema; Hb-hemoglobin; TSI- transferrin saturation index; Ca-calcium; P-phosphorus; AF-alkaline phosphatase; PTH- parathyroid hormone; K-potassium; KtV- kinetic urea removal index; MIS- malnutrition and inflammation score; SAHLPA- Short Assessment of Health Literacy for Portuguese-speaking in Adults; SF-12- Short Form-12 quality of life score; SPSS- Scale of Perceived Social Support; ACEIs/ARBs- angiotensin-converting enzyme inhibitors/angiotensin II receptor blockers.

In patients for whom phosphorus control was more common at the goal, we observed older age (p=0.04), etiologies other than autossomic dominant polycystic

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kidney disease (p = 0.02) and the presence of congestive heart failure (p = 0. 03) and, paradoxically, the lack of previous nephrological follow-up (p = 0.05). Calcium levels were better controlled in brown patients (p = 0.04), those with lower MIS [16] (p = 0.05), those with lower practical SPSS [14] (p = 0.04) and those with lower hospitalization rates (p = 0.04). PTHi was better controlled in nonobese individuals (p = 0.02) and among those who had not undergone previous HD (p = 0.04) (*Figure 4*). In the evaluation of glucose, diabetic patients were more likely to be out of target (p = 0.001), and those who were younger (p = 0.005), were without dementia (p = 0.05), had more previous nephrological follow-up (p = 0.05) or had a worse physical component of the SF-12 [15] (p = 0.017) were among those who were on target (*Figure 4*).

Patients who met the potassium goal had a higher income (p = 0.03), nondiabetic CKD etiology (p = 0.003) and less progress to death (p = 0.05) (*Figure 4*).

Albumin achieved better results in non-dementia patients (p = 0.04), in those who did not undergo previous PD (p = 0.04) and in those who did not have peritonitis (p = 0.02). Patients with higher KtV [12] levels were more adherent (p = 0.008) and had a lower percentage of hospitalizations (p = 0.04) (*Figure 4*).

We observed relative heterogeneity in the determinants of the goals that may be due to the sample size. However, several factors, such as age, dementia status, DM status and previous nephrological follow-up, strongly interfered with several goals (*Figure 4*).

Outcomes

Regarding the secondary outcomes, 32 patients were admitted to the hospital (57.1%), 20 of whom were prevalent (48.8%) and 12 of whom were incident (80%), revealing that there were more hospitalizations among incident cases (p = 0.03). Among those of the 39 hospitalizations, the main etiology responsible for hospitalization was sepsis unrelated to PD (12 patients or 30.8%), notably due to respiratory, urinary tract and skin infections.

ESI occurred in 18 cases (32.1%), 10 of which were prevalent cases (24.4%) and eight of which were incident patients (53.3%), and there were no tunnel infections. There was a higher proportion of ESI in incident patients (p = 0.05). Peritonitis occurred in seven patients (12.5%), four of whom were prevalent patients (9.8%) and three of whom were incident patients (20%) (p = 0.37). Eight individuals (14,3%) were affected by mechanical complications, including leakage (4), hernias (2), catheter translocation (1), and pleuroperitoneal fistula (1). These events occurred in seven incidents (46.6%) but in only one prevalent patient (2.4%) (p = 0.001) .

Changes in technique occurred in 10 patients (17.8%), one who received a transplant (1.8%) and nine who were referred for HD (16%). One-third of the incident patients were transferred to HD, which was a higher percentage than that of prevalent patients (9.8%) (p = 0.09). The main reasons were poor adherence to therapy (4), peritonitis (3), pleuroperitoneal fistula (1) and UF failure (1). During follow-up, there were 23.2% deaths, 26.8% of which were prevalent and 13.3% of which were incident patients. It is noteworthy that the deaths among incident cases occurred in those with less than three months of therapy. Sepsis unrelated to PD was identified as the main cause of death in eight cases (62%), six of which were prevalent and two were incident patients. There were three deaths due to cardiovascular disease (23%) and two deaths due to coronavirus disease (COVID-19) (15.4%), all of which were prevalent patients. It should be noted that there was no record of death due to sepsis associated with PD.

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Table 2 - Logistic regression with the outcome variable hospital admission

Variable	OR	p-value	Confidence Interval 95%	
			Lower Limit	Upper Limit
Age	0.972	0.354	0.916	1.032
Female Sex	0.882	0.887	0.157	4.960
DM (No)	0.154	0.026	0.030	0.800
MIS	1.105	0.354	0.895	1.365
KtV	0.580	0.198	0.253	1.328
Diuresis	1.002	0.034	1.000	1.003

Caption: *OR (Odds Ratio); % (percentage); DM (diabetes mellitus); MIS (malnutrition inflammation score); KtV (urea kinetic adequacy index);*

Nevertheless, regarding secondary outcomes within the multivariate analysis model with the outcome variable hospitalization, higher diuresis were associated with more hospitalization and those patients without diabetes presented lower incidence of hospitalization (*Table 2*). With regard to the multivariate analysis, it was not possible to find a model with adequate analysis of residues that correlated PD discontinuation with other variables.

We evaluated the primary outcomes in a multivariate model after performing multiple adjustments for confounders, with the outcome variable QoL analyzed separately for its physical and mental components (*Table 3.1*) and death (*Table 3.2*).

In a linear regression model, with the physical component of the SF-12 [15] (PCS-12) as the dependent variable, we observed that only the MIS [16] score showed a negative correlation (Table 3). In the analysis of the mental component of the SF-12 [15] (MCS-12) as the dependent variable, only age was negatively correlated (*Table 3*). There was no significant difference in the outcome of death.

Table 3 - Linear regression with the physical component (PCS-12) and mental component (MCS-12) of the SF-12 as the outcome variable

Dependent variable PCS-12	RR	p-value	Confidence Interval 95%	
Independent variables			Lower Limit	Upper Limit
Age	-0.201	0.245	-0.394	0.105
Female Sex	-0.106	0.525	-8.410	4.391
DM (Yes)	0.284	0.078	-0.712	12.535
MIS	-0.455	0.007	-1.953	-0.348
KtV	0.241	0.142	-1.277	8.434
Diuresis	-0.104	0.535	-0.008	0.004
Dependent variable MCS-12	RR	p-value	Confidence Interval 95%	
Independent variables			Lower Limit	Upper Limit
Age	-0.397	0.035	-0.600	- 0.023
Female Sex	-0.319	0.077	-14.028	0.761
DM (Yes)	0.192	0.250	-12.033	3.272
MIS	-0.452	0.075	-0.089	1.764
KtV	0.123	0.470	-7.615	3.604
Diuresis	-0.072	0.683	-0.008	0.006

Caption*: PCS-12 (physical component score of SF-12); RR (Relative Risk); % (percentage); DM (diabetes mellitus); MIS (malnutrition inflammation score); KtV (urea kinetic adequacy index); MCS-12 (mental component of SF-12).*

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DISCUSSION

Our study analyzed the profile of PD patients at a Brazilian Public University Hospital to understand who they are and how adapted they were to the method. We evaluated which goals of dialysis adequacy were appropriately achieved and which variables interfered with this objective. Subsequently, we evaluated whether achieving these goals interfered with the outcomes. It is worth noting that in Brazil, there is no policy to encourage the inclusion of patients in PD and the cost of this therapy for the service provider is higher than that paid by the public health system. We emphasize that we strictly determined adherence to the goal as 80% of the study time within the parameters. A systematic review performed by Griva et al. [18] demonstrated that nonadherence is a determining factor of PD outcomes, and the reported rates varied among studies. There were large methodological differences in the measurement and definition of nonadherence, showing that there is no consensus on the subject [18].

We observed a sample of elderly patients who were low in income and education, who were dependent on caregivers, who received social support and often who previously received other KRT. In addition, we observed a high prevalence of comorbidities, polypharmacy and poor quality of life. By comparing this study with a Brazilian multicenter study, we observed that the same negative bias regarding PD indications persists [4]. On the other hand, in France, in the year 2022, 59% of patients were independent in their PD treatment, with 36% assisted by a nurse and 5% by a family member [19]. Furthermore, 68.5% of patients were over 60 years of age [19]. Regarding health literacy, a Brazilian study showed that educational level assessed by years of study did not impact patient and technique survival over a 3-year period [20].

Regarding the goals, ISPD defined a BP greater than 140/90 mmHg as systemic arterial hypertension (SAH) [21]. Within this target, a recent review on hypertension in PD patients indicated that 70-80% were hypertensive [22]. Cocchi et al. [23] showed that 88% of patients on PD were hypertensive and 77% had inadequate control [23]. Patients on PD are more prone to hypervolemia than are those on HD due to the slower removal of fluids and electrolytes. On the other hand, these patients have less intradialytic hypotension and greater preservation of KRF [22]. Similarly, our study demonstrated a high prevalence of SAH, and only 30.4% of the patients achieved control. Among the factors that contributed to the difficulty of control, we highlighted younger age and nonadherence to the method [24,25].

Regarding volume control in PD patients, studies have shown worst control with this modality [26,27]. The presence of edema and imaging tests were used in the volume assessment in our study. Despite being useful in aiding volume control, Ferreira-Filho et al. [28] demonstrated in a cohort of incident on PD that only 28% of those with edema were hypervolemic according to other criteria [28,29]. Another factor that may be related to blood volume control is the decrease of RKF [22]. The absence of icodextrin-based solutions may have contributed to volemic imbalance in some patients, but we are unable to make this inference.

Recent data from the National Health and Nutrition Examination Survey (NHANES) revealed that the rate of anemia in CKD patients was twice as prevalent in people with CKD (15.4%) as in the general population (7.6%) and increased with stage of CKD, from 8.4% at stage 1 to 53.4% at stage 5 [30].The Peritoneal Dialysis Outcomes Practice Patterns (PDOPPS) study on anemia in PD patients revealed that between 16% and 23% of patients had Hb levels less than 10 g/dL [31]. Our study revealed appropriate control in 42.9% of the subjects. There was wide use of Epo,

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reaching 83.9%, which is consistent with data indicating 94% of Epo in Japan and 79% in the United States [31]. Similarly to the control of Hb, ferritin and STI reached the desired target in less than 40% of the samples, with low venous use of iron salts. Data from the PDOPPS are not very different and indicate low use of venous iron in this population (6-17%), with the exception of the United States (55%) [31].

The main factor associated with adequate Hb control in our study was the presence of previous nephrological follow-up. Another important study showed that prior nephrological follow-up and not the variability of Hb, was a predictor of mortality in a large cohort of PD patients [32]. Phosphorus was the most difficult laboratory goal to achieve. This occurred among younger and obese individuals, who likely had lower dietary adherence and lower adherence to the dialysis method. It's important to note that younger patients presented more previous nephrological follow-up (data do not show). Cernaro et al. [33] reported that the removal of peritoneal phosphate occurs by diffusion and convection and that although the molecular weight of phosphate is only 96 Daltons, its peritoneal transport is more complex than that of urea and creatinine, acting as an average molecule in PD [33]. In a prospective study, Courivaud et al. [34] suggested that the removal of peritoneal phosphate could be optimized by increasing the volume of dialysate and the duration of dwell, according to the PET of the patient [34]. In our study, we did not observe an association between phosphate levels and PET.

Data from the Australian and New Zealand Dialysis and Transplant Registry showed a high risk of mortality attributed to hyperphosphatemia among those incidents in KRT [35]. On the other hand, our study did not reveal higher risks of adverse outcomes related to not achieving this goal.

Glucose was out of control in all patients with diabetes in our study. Abe et al. [36] evaluated the levels of glycated hemoglobin and glycated albumin in patients on PD and noted that only high levels of glycated albumin were associated with increased mortality [36].

Malnutrition is known to be associated with increased mortality in PD patients [16]. In our study, worst albumin levels were associated with dementia and episodes of peritonitis, which is consistent with previously published studies [37,38]. This may be explained by the fact that patients with peritonitis or previous PD lost more albumin in the peritoneal effluent and dementia patients are more malnourished. [37,38].

Potassium was well controlled and was associated with increased mortality in several studies [39-41]. According to our bivariate analysis, poorer potassium control was associated with increased mortality. However, in multivariate models that included potassium, this did not occur.

Regarding the causes associated with the higher prevalence of hospitalizations, this occurred more frequently in incident patients. This can be explained by the selection bias of incident patients who arrived at the method in worse clinical conditions. This same fact may explain why patients with higher diuresis were hospitalized more, as prevalent patients have lower diuresis. Regarding DM, non-DM patients had a lower prevalence of hospitalization, which can be observed in other studies.

Approximately one-third of the patients presented with ESI, and there was a low overall rate of peritonitis, which was 0.17 episodes/patient/year [17]. Nevertheless, among seven peritonitis, PD discontinuation occurred in three patients (43% of these).

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We demonstrated good adequacy for small solutes, and focusing on the individualization of adequacy, we evaluated QoL through the SF-12 [15], which showed low scores for the physical and mental components. By analyzing QoL as an outcome, we observed that for the PCS-12, higher MIS [16] and, consequently, worst nutritional status were predictors of worst QoL. The presence of DM, despite not being statistically significant, was clinically associated with worsening of this component. According to the MCS-12, older age was independently related to worst scores. QoL was also assessed by Grincenkov et al. [42] in a large cohort of PD patients and was independently associated with age and mortality [42].

The limitations of our study include a short period of observation time, which prevented us from evaluating metabolic complications and constructing adequate multivariate models for PD discontinuation and mortality.

CONCLUSION

In conclusion, achieving BP, Hb and phosphate targets was our greatest challenge. The factors that were most significantly associated with the achievement of goals were age, previous nephrological follow-up, presence of dementia, DM, adherence to technique and health literacy. We conclude that efforts to improve the factor most susceptible to intervention, which is adherence to the therapy prescription and drugs, will help to improve patient compliance.

Ethical approval

Research ethics boards at the Federal University of Juiz de Fora, Minas Gerais, Brazil, under no 5.001.893. All patients signed the informed consent.

Declaration of conflicting interests

The authors declare no conflict of interest

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Author contributions

All authors fulfill criteria for authorship in that they (i) made a substantial contribution to the concept or design of the work; or acquisition, analysis or interpretation of data; (ii) drafted the article or revised it critically for important intellectual content; and (iii) approved the version to be published. All authors meet all three criteria of authorship listed above.

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