Renal Replacement Therapy

RESEARCH

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Factors predicting post-dialysis fatigue of maintenance hemodialysis patients

Huiwen Li[1†], Jinmei Yin[1†], Yi Dong[1] and Zhiwu Tian[1*]

Abstract

Aims Post-dialysis fatigue is a common complication in maintenance hemodialysis patients. This study aims to evaluate post-dialysis fatigue and discover related risk factors.

Design and methods In this cross-sectional study, we used the specific scale to measure post-dialysis fatigue of maintenance hemodialysis patients from June to September 2021, and looked for risk factors from sociodemographic and clinical data.

Results The post-dialysis fatigue score for 147 maintenance hemodialysis patients was 14.75 ± 8.24. The post-dialysis fatigue was associated with increasing age ($b = 2.00$, $p = 0.016$), fewer dialytic vintages ($b = -1.91$, $p = 0.001$), increasing inter-dialysis weight gain ($b = 5.79$, $p < 0.01$), decreasing hemoglobin ($b = -3.30$, $p = 0.011$) and Kt/V ($b = -2.74$, $p = 0.035$).

Conclusions Patients with old age, dialytic vintage less than 36 months, poor control of inter-dialysis weight gain, anemia, and inadequate dialysis are more likely to suffer from post-dialysis fatigue.

Keywords Dialysis, Fatigue, Post-dialysis fatigue, Maintenance hemodialysis, Time to recover from dialysis

Introduction

For patients with end-stage renal disease (ESRD), kidney transplantation, peritoneal dialysis and hemodialysis are the main methods to prolong their lives and improve their quality of life [1]. As the most commonly used technique in renal replacement therapy, hemodialysis has played an important role in prolonging the life expectancy of ESRD patients [2]. For maintenance hemodialysis (MHD) patients, while enjoying the prolonged life, they are also bearing the undesirable symptoms that accompany hemodialysis, such as fatigue, especially post-dialysis fatigue (PDF) [3].

MHD patients should be able to return to society in a better condition after hemodialysis, but the appearance of PDF has made it more difficult [4]. Different from the persistent fatigue caused by chronic diseases, PDF is a kind of discomfort after hemodialysis. It is often described as MHD patients feeling tired or exhausted and requiring rest or sleep after the dialysis session [5]. PDF is regarded as one of the indicators of debilitating MHD patients, and it is usually the main reason for patients' unwillingness to comply with the best dialysis prescriptions [3]. Therefore, we should attach sufficient attention to PDF to ensure the effectiveness of treatment.

There are not many studies on PDF, and the measurement tools and evaluation criteria are different. Some studies used open-ended questions to understand the degree of fatigue of patients [5, 6], some studies used the time to recover from dialysis (TIRD) to indirectly measure the degree of fatigue of patients [3, 7–9], some studies focused on using the fatigue-specific PROM (patient-reported outcome measure) as a measure of fatigue

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in the dialysis population [10, 11]. It is difficult to truly grasp the current status of PDF in MHD patients through existing studies, but we can still use the existing results as a reference to get a preliminary understanding of the relevant information about PDF. A multi-center study on PDF found that 60.5% of MHD patients had PDF, of which 22.1% were moderate PDF and 38.4% were severe PDF [8]. Among MHD patients who have been on hemodialysis for more than 1 year, 74% of patients have PDF, and nearly 50% of patients have a recovery time of more than 2 h after dialysis [7]. The prevalence and severity of PDF in MHD patients should be given enough attention.

According to the existing studies, we can think that the appearance of PDF is associated with higher mortality, higher hospitalization and worse mental state of MHD patients [9, 12]. But it is still not clear for us to understand the causes of PDF. Some studies have found that lactic acid level and interleukin-10 (IL-10) are related to PDF from the perspective of biochemistry [6, 7], some studies have found that sedentary behavior and daily activity ability are related to PDF from the perspective of lifestyle [8, 13, 14], and some studies have found that the ultrafiltration rate and inter-dialysis weight gain (IDWG) are related to PDF from the perspective of dialysis [5, 9].

Therefore, this study aims to use a dedicated rating scale to evaluate PDF in MHD patients and discover related risk factors to deepen the understanding of PDF among researchers and clinicians and provide a theoretical basis for future interventions.

Materials and methods

This was a single-center cross-sectional study in the Blood Purification Center from June 2021 to September 2021. This study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: Guidelines for Reporting Observational Studies. All participants signed informed consent. This study has been approved by the ethics committee of our hospital.

Participants

In this study, we recruited ESRD patients with stable clinical characteristics and receiving hemodialysis for more than 6 months. All patients were able to go to the center for hemodialysis on their own. Considering other disease-related factors that may have an impact on the patient's fatigue, we excluded patients with the following conditions: severe cardiovascular and cerebrovascular diseases, mental illness that is difficult to diagnose and treat, surgery within the past month, and acute infections. All patients received hemodialysis 3 times a week for 4 h each time, using standard bicarbonate dialysate. The dialysate flow was 500 mL/min and the blood flow was 200–300 mL/min. All dialyzers used biocompatible membranes. This study adopted convenient sampling method. In this study, 14 predictors were selected. According to the empirical formula, the sample size should be 5–10 times of the number of predictors. Considering 20% unqualified questionnaires, the minimum sample size of this study is $14*5*(1+20\%)=84$. All participants signed informed consent forms. This study has been approved by the ethics committee of our hospital.

Data collection and measurements

Electronic information systems are used to extract relevant information about patients, including gender, age, occupation, primary diseases of ESRD, dialytic vintage, height, dry weight, body mass index (BMI), weight before and after dialysis, hemodialysis mode (Hemodialysis = HD, Hemodiafiltration = HDF, Hemodialysis and Hemoperfusion = HD + HP), ultrafiltration volume, systolic blood pressure before and after dialysis, and blood biochemical results (including hemoglobin, serum albumin, predialysis potassium and predialysis phosphorus), Kt/V, etc.

We have integrated some of the original data and converted it into another variable for statistical analysis, such as inter-dialysis weight gain. The difference in systolic blood pressure before and after dialysis is used to judge the patient's blood pressure stability (If the absolute value of the difference is within 20 mmHg, we believe that the patient's blood pressure is stable in this dialysis session).

Regarding the collection of blood samples, according to the requirements of *Blood Purification Standard Operating Procedure* [15], the hemodialysis specialist nurse collected blood from the patient's arteriovenous fistula (AVF) or central venous catheter (CVC) before and after dialysis and sent it to the laboratory for evaluation of hemoglobin, serum albumin, potassium and phosphorus in the blood. The evaluation of all laboratory data was based on the recommendations of *the Chinese Hemodialysis Adequacy Clinical Practice Guidelines* [16].

PDF measurement

There are three methods that have been used to assess PDF. The first is to use the simple visual analogue scale (VAS), which is, in general, used as a measure of the level of fatigue experienced by individuals after undergoing hemodialysis. The second is to use TIRD to evaluate the PDF indirectly. TIRD is an open-ended question asked by the investigator to the patients: how long will it take for you to recover to a healthy state after dialysis treatment [17]. This question was easily understood by patients and widely used by researchers and clinicians. The third, and innovative aspect of this study, is to use the PDF scale developed by Kodama [18] to directly evaluate PDF.

Previous studies on PDF extracted some questions from a complete scale to measure PDF, which undoubtedly destroyed the integrity of the scale. Unlike these scales, the PDF scale is a complete scale specifically developed to evaluate post-dialysis fatigue in MHD patients. This was a self-rating scale containing 13 items. The content of the scale is the adverse symptoms of the patients after dialysis, including fatigue, general malaise, feeling exhausted and weak, lightheadedness, need to lie down and take a nap or rest, difficulty moving without taking a nap or rest, no appetite, headache, thoracic discomfort, toothache, not wanting to move, not being motivated to do anything and feeling pain after dialysis and eventually doing nothing for the whole day. These symptoms are evaluated on a 5-point scale, ranging from "very severe" or "strongly agree" to "not at all" or "absolutely not applicable". The higher the patient's self-score, the more severe the PDF. The cumulative variance contribution rate of the scale in the hemodialysis population was 51.08%, and the Cronbach's alpha was 0.924 [18].

Our center conducted blood sampling for patients on a regular basis to facilitate timely adjustment of the dialysis program. Blood was collected before and after dialysis to evaluate the effect of the dialysis. The PDF measured in this study was exactly the patients' fatigue after this dialysis. Because the patients were on regular dialysis, we administrated the questionnaire face-to-face to the patients at the next dialysis treatment. Therefore, the time interval between blood collection and questionnaire administration was 2–3 days.

Statistical analysis

Continuous variables with normal distributions were presented as mean ± standard deviation (SD), and those without normal distributions as the median (interquartile range), categorical variables as number (percentage). Differences between groups were analyzed with independent-samples *t* test or one-way ANOVA, and the LSD (Least—Significant Difference) method was used to make multiple comparisons between groups. Pearson correlation coefficient was used to test the relationship between TIRD and PDF scores. We use multivariate regression to analyze the risk factors of PDF. P value < 0.05 was considered statistically significant. All statistical analysis was completed in SPSS 25.0 software.

Results

Relationship between VAS, PDF score and TIRD

In this study, we evaluated the internal consistency reliability of the PDF scale and the correlation between the items using the Cronbach's α and corrected item-total correlation (CITC). The results showed that the Cronbach's α was 0.851 and the CITC value ranged from 0.284 to 0.691 (Table 1), indicating that the scale had good reliability and reasonable correlation among the items.

Table 1 Results of the reliability analysis of the PDF scale

Item	Corrected item-total correlation	Cronbach' α if item deleted	Cronbach' α
Q1	0.534	0.839	0.851
Q2	0.483	0.842	
Q3	0.412	0.847	
Q4	0.624	0.834	
Q5	0.654	0.830	
Q6	0.691	0.828	
Q7	0.620	0.834	
Q8	0.284	0.853	
Q9	0.413	0.847	
Q10	0.312	0.852	
Q11	0.590	0.835	
Q12	0.521	0.840	
Q13	0.432	0.845	

Q1 Fatigue, *Q2* General malaise, *Q3* Feeling exhausted and weak, *Q4* Lightheadedness, *Q5* Need to lie down and take a nap or rest, *Q6* Difficulty moving without taking a nap or rest, *Q7* No appetite, *Q8* Headache, *Q9* Thoracic discomfort, *Q10* Toothache, *Q11* Not wanting to move, *Q12* Not being motivated to do anything, *Q13* Feeling pain after dialysis and eventually doing nothing for the whole day (same below)

Table 2 Correlation analysis results of VAS, TIRD and PDF (r)

Item	VAS	TIRD
Q1	0.578**	0.489**
Q2	0.474**	0.364**
Q3	0.374**	0.229**
Q4	0.587**	0.477**
Q5	0.602**	0.474**
Q6	0.660**	0.483**
Q7	0.607**	0.485**
Q8	0.351**	0.340**
Q9	0.447**	0.338**
Q10	0.283**	0.312**
Q11	0.590**	0.441**
Q12	0.511**	0.563**
Q13	0.395**	0.268**
PDF	0.836**	0.682**

**P < 0.01

In this study, the VAS was 4.55 ± 2.09 and the TIRD was 2.64 ± 2.42 h. The PDF was 14.75 ± 8.24 (0–33), and no patients showed particularly high PDF. The results of the correlation analysis showed that the PDF and its items had *r*-value between 0.283 and 0.836 with the VAS and between 0.229 and 0.682 with the TIRD (Table 2), further confirming the reliability and stability

of the PDF scale. The next statistical analysis used PDF score as the dependent variable instead of TIRD.

Participants characteristics

A total of 147 MHD patients were included in this study. Their demographic characteristics, clinical characteristics were shown in Table 3. The mean age was 51.63 ± 12.14 years (range from 20 to 83 years), and male patients accounted for 59.9%. The PDF score of patients over 60 years old was significantly higher than that of patients younger than 60 years old ($p < 0.01$), but there was no difference in PDF score between male and female patients ($p = 0.069$). Patients employed accounted for 74.1%, and their PDF score was significantly higher than those unemployed ($p = 0.011$). The median (interquartile range) for dialytic vintage (months) was 52 (33, 98). Glomerulonephritis accounted for 63.9% of all primary causes of ESRD. According to the recommendations of the guidelines, the IDWG within a reasonable range (less than 5% dry weight) of patients accounted for 69.4%. In the clinical characteristics, except for the dialysis vintage and IDWG ($p = 0.027$ and $p < 0.01$, respectively), other factors, including primary causes of ESRD, BMI, change in SBP and hemodialysis mode, were not associated with PDF ($p > 0.05$).

Table 4 showed the differences in the laboratory parameters of the PDF score in MHD patients. Sixty-eight percent of patients had hemoglobin levels above 100 g/L, and their PDF score was significantly lower than those of patients with hemoglobin levels below 100 g/L ($p < 0.01$). The Kt/V levels of 70.1% of patients reached the range recommended by the guidelines (≥ 1.2). Compared with patients with Kt/V levels less than 1.2, the PDF score of the former was significantly lower ($p = 0.042$). As for serum albumin, predialysis K and predialysis P, there was no statistically significant difference between the groups in their PDF scores.

Risk factors of PDF

We performed multiple linear regression analysis on the statistically significant related factors in the above results to determine the influencing factors of PDF in MHD patients. The results showed that the risk factors of PDF were age ($b = 2.00$, $p = 0.016$), dialysis vintage ($b = -1.91$, $p = 0.001$), IDWG ($b = 5.79$, $p < 0.01$), hemoglobin ($b = -3.30$, $p = 0.011$) and Kt/V ($b = -2.74$, $p = 0.035$) ($R^2 = 0.315$, $F = 10.724$, $p < 0.01$; Table 5).

Discussion

This study was one of the few to directly measure the PDF of MHD patients in the form of a scale, and used TIRD to measure the PDF indirectly. TIRD could be used as a simple tool to quickly evaluate the PDF of MHD patients. The primary finding of this study was that the PDF of MHD patients was 14.75 ± 8.24, and no patients showed particularly high PDF. The PDF of MHD patients was associated with age more than 60 years, dialytic vintage less than 36 months, increasing IDWG, decreasing hemoglobin and insufficient dialysis.

Among the demographic factors, this study found that the age over 60 was an independent risk factor for PDF in MHD patients. Compared with other studies that have found that there was no age difference in PDF of MHD patients, this finding was novel and worthy of reflection [5, 7]. One possible explanation was that compared with younger people, older people have more chronic disease symptoms, slower recovery of body functions, and poor tolerance [1]. For example, most elderly patients with MHD were accompanied by blood pressure instability, whether it was hypotension or hypertension. During dialysis, as antihypertensive drugs were partially removed or the ultrafiltration volume increased, the adverse effects of blood pressure changes on such patients appeared, and this result was often considered to be caused by dialysis. Therefore, the PDF of elderly patients with MHD appeared to be severe. As for the relationship between employment and PDF, the results of this study were inconsistent with previous results. The reason for this result may be related to occupational type and work intensity, and the exact conclusion needs further research to verify.

From the perspective of dialysis factors, dialytic vintage and IDWG were independent risk factors for PDF in MHD patients, and IDWG was an important risk factor. Our study found that the PDF of MHD patients within 36 months of dialytic vintage was relatively severer, which was contrary to the results of previous studies that found that PDF increased with the increase of dialytic vintage [7]. This phenomenon may be related to the following reasons. First, although patients have been on hemodialysis for more than 6 months, there are still some patients who are in the vascular access selection phase for vascular reasons or for fear of pain, especially arteriovenous fistula (AVF) and central venous catheter (CVC). Second, most patients are expected to work, and due to hemodialysis 2–3 times a week, they have difficulty coordinating or finding a suitable job in a short period of time, and they have to meet their work demands by reducing their dialysis time, which undoubtedly increases the PDF. Third, as patients' old habits are broken and new habits have not yet been formed, the dry weight, water intake, and urine output are constantly changing. Failure to assess and adjust for these changes in a timely manner can also result in poorly set dialysis prescriptions and increased patients' fatigue. Given that most of the above reasons are specific realities of dialysis treatment in our

Table 3 Demographic and clinical characteristics of the MHD patients (n = 147)

Characteristic	Frequency (percentage, %)	PDF score (mean ± SD)	*p* value
Gender			0.069
Male	88 (59.9)	13.74 ± 8.07	
Female	59 (40.1)	16.25 ± 8.33	
Age, years			< 0.01
≤ 44	45 (30.6)	14.36 ± 7.76	0.191 (v.s. 45–59)
45–59	61 (41.5)	12.33 ± 7.85	< 0.01 (v.s. ≥ 60)
≥ 60	41 (27.9)	18.78 ± 7.96	0.010 (v.s. ≤ 44)
Employment			0.011
Employed	109 (74.1)	15.76 ± 8.40	
Unemployed	38 (25.9)	11.84 ± 7.08	
Primary causes of ESRD			0.439
Glomerulonephritis	94 (63.9)	14.23 ± 7.87	0.465 (v.s. Diabetes) 0.939 (v.s. Hypertension)
Diabetes	29 (19.7)	15.52 ± 8.96	0.646 (v.s. Hypertension) 0.855 (v.s. Immune disease)
Hypertension	8 (5.4)	14.00 ± 10.21	0.791 (v.s. Immune disease) 0.115 (v.s. Others)
Immune disease	12 (8.2)	15.00 ± 7.77	0.762 (v.s. Glomerulonephritis) 0.144 (v.s. Others)
Others	4 (2.7)	22.00 ± 9.27	0.067 (v.s. Glomerulonephritis) 0.143 (v.s. Diabetes)
Dialytic vintage, months			0.027
≤ 36	47 (32.0)	17.26 ± 8.36	0.242 (v.s. 37–60) 0.012 (v.s. 61–120)
37–60	39 (26.5)	15.21 ± 7.29	0.194 (v.s. 61–120) 0.138 (v.s. > 120)
61–120	39 (26.5)	12.82 ± 8.59	0.703 (v.s. > 120)
> 120	22 (15.0)	12.00 ± 7.75	0.013 (v.s. ≤ 36)
BMI			0.116
≤ 18.4	22 (15.0)	13.82 ± 7.38	0.454 (v.s. 18.5–23.9) 0.575 (v.s. 24.0–27.9)
18.5–23.9	88 (59.9)	15.28 ± 8.51	0.117 (v.s. 24.0–27.9) 0.122 (v.s. ≥ 28.0)
24.0–27.9	29 (19.7)	12.52 ± 7.65	0.026 (v.s. ≥ 28.0)
≥ 28.0	7 (4.8)	20.29 ± 8.48	0.071 (v.s. ≤ 18.4)
IDWG, kg			< 0.01
≤ 5% dry weight	102 (69.4)	13.02 ± 7.74	
> 5% dry weight	45 (30.6)	18.67 ± 8.08	
Change in SBP, mmHg			0.220
≤ 20 mmHg	110 (74.8)	14.26 ± 8.35	
> 20 mmHg	37 (25.2)	16.19 ± 7.84	
Hemodialysis mode			0.983
HD	93 (63.3)	14.70 ± 8.52	0.958 (v.s. HDF)
HDF	49 (33.3)	14.78 ± 8.00	0.873 (v.s. HD + HP)
HD + HP	5 (3.4)	15.40 ± 6.39	0.854 (v.s. HD)

ESRD End-stage Renal Disease, *BMI* Body Mass Index, *IDWG* Inter-dialysis Weight Gain, *SBP* Systolic Pressure, *HD* Hemodialysis, *HDF* Hemodiafiltration, *HD + HP* Hemodialysis and Hemoperfusion

centre, we cannot exclude the possibility that high PDF cases tend to die within 36 months, and this result may not apply to other areas as well. Despite this, we can still take the following measures to face these situations. On the one hand, patients need to adjust their living conditions and habits to adapt to their future dialysis life; on

Table 4 Laboratory parameters of the MHD patients (n = 147)

Characteristic	Frequency (percentage, %)	PDF Score (mean ± SD)	*p* value
Hemoglobin, g/L			< 0.01
≥ 100	100 (68.0)	12.96 ± 8.18	
< 100	47 (32.0)	18.55 ± 7.05	
Serum albumin, g/L			0.950
≥ 35	131 (89.1)	14.76 ± 8.09	
< 35	16 (10.9)	14.63 ± 9.65	
Predialysis K, mmol/L			0.510
≤ 5.5	118 (80.3)	14.53 ± 8.37	
> 5.5	29 (19.7)	15.66 ± 7.76	
Predialysis P, mmol/L			
≤ 1.78	88 (59.9)	15.41 ± 8.42	
> 1.78	59 (40.1)	13.76 ± 7.93	
Kt/V			0.042
≥ 1.2	103 (70.1)	13.84 ± 8.03	
< 1.2	44 (29.9)	16.86 ± 8.43	

K Potassium, *P* Phosphorus, *Kt/V* Urea clearance

the other hand, we should improve management measures, dynamically adjust dialysis prescriptions, and improve dialysis quality to reduce PDF.

In addition, unlike previous negative results that IDWG and PDF were not related, this study found that PDF in MHD patients was significantly correlated with increased IDWG [8]. As a reference indicator of the ultrafiltration volume during a dialysis session, IDWG affected the quality of dialysis of MHD patients [19]. The increasing IDWG meant that the water in the patient's body increased, which caused a burden on the body and the heart, which could easily lead to symptoms such as heart failure and high blood pressure [20]. The primary purpose of hemodialysis in patients with MHD was to remove excess water from the body, but in order to ensure the reperfusion balance of various organs and reduce complications such as cramps and hypotension, the ultrafiltration volume of a single dialysis was generally not more than 5% of dry weight [15]. With the increase of IDWG, the ultrafiltration volume was increasing, the hemodynamics of patients during dialysis became unstable, and it was more likely to cause dialysis complications such as acute cardiac ischemia and abnormal regional wall motion and caused PDF [21, 22]. If the IDWG of MHD patients increased too much, the effective way was to increase the number of dialysis instead of increasing the ultrafiltration volume in a single dialysis, which could not only ensure the quality of dialysis, but also reduce PDF.

The results of the relationship between laboratory indicators and PDF for MHD patients were unexpected but reasonable. After all, the findings of previous studies on the relationship between the two were not consistent [6, 8]. This study found that the PDF of MHD patients increased with the decrease of hemoglobin and Kt/V. As one of the most powerful indicators of anemia, the reduction of hemoglobin could easily induce fatigue in MHD patients [23]. However, the hemoglobin of MHD patients was often stable because of erythropoietin and iron. Therefore, the increase of fatigue caused by the decrease of hemoglobin would not only appear after dialysis, but also before dialysis, even on non-dialysis days, which could be the reason for the inconsistent results of related studies. Kt/V represented the adequacy of dialysis, and its increase represented an increase in the clearance rate of small molecule toxins such as urea by dialysis, the body burden of MHD patients was reduced, and the PDF was reduced.

This study used a newly developed PDF-specific scale to evaluate the PDF of MHD patients, with the expectation of standardizing the evaluation of PDF and providing new directions for future research on PDF. In addition, the participants in this study were all patients undergoing long-term hemodialysis in our center, and the investigators were all their nurses in charge, who had a considerable understanding of their basic

Table 5 Multiple regression analysis with PDF as dependent variable (n = 147)

Predictor variables	*b*	*SE B*	*β*	*t*	*p*	95% CI
Constant	15.61	1.87	–	8.35	< 0.01	11.91, 19.30
Age	2.00	0.82	0.19	2.44	0.016	0.38, 3.61
Employment	2.65	1.43	0.14	1.86	0.066	− 0.17, 5.47
Dialytic vintage	− 1.91	0.55	− 0.25	− 3.47	0.001	− 2.99, − 0.82
IDWG	5.79	1.28	0.33	4.51	< 0.01	3.25, 8.32
Hemoglobin	− 3.30	1.29	− 0.19	− 2.56	0.011	− 5.84, − 0.76
Kt/V	− 2.74	1.28	− 0.15	− 2.13	0.035	− 5.27, − 0.20

$R^2 = 0.315$, $F = 10.724$, $p < 0.01$

b Regression coefficient, *SE B* Standard error of *b*, *β* Standardized regression coefficient, *CI* Confidence interval, *IDWG* Inter-dialysis Weight Gain, *Kt/V* Urea clearance

information and disease status, thus ensuring the validity of the questionnaire data.

Some limitations of this study need to be noted. First of all, the scale used in this study were developed recently, and the scope of use was relatively small. On the one hand, this study may have benefited more by the use of value graded scaling like from 1 to 10 for each symptom rather than a 5-point scale. On the other hand, there may be some differences when comparing the results of other studies. Future studies can compare the objective results evaluated using the scale with the results subjectively felt by patients in order to complete the measurement of PDF from multiple perspectives and improve the PDF scale. In addition, this study used the face-to-face questionnaire method, in which the investigator asked the patients about their fatigue after the last dialysis. Due to the frequency of dialysis in MHD patients, the time of questionnaire administration will be 2–3 days away from the last dialysis time. Therefore, patients may have recall bias, and we cannot accurately determine whether their responses were about fatigue after the last dialysis or chronic fatigue throughout the dialysis period. Telephone follow-up on the second day of dialysis for MHD patients may be a better way to investigate. Moreover, this study was a single-center, cross-sectional study with a small sample size and slightly underrepresented, which also contributed to the suboptimal Cronbach's coefficient alpha of the PDF scale in this study. Finally, the time span we set for the analysis vintage is too large, resulting in too many confounding factors, so the impact of the dialysis vintage on the PDF may be unstable. In future studies, we will consider collaborating with other centers to expand the sample size, increase sample diversity, control for confounding factors, and perform the necessary stratified analysis to improve the stability of the results.

Conclusion

In conclusion, PDF was ubiquitous in MHD patients and should be given enough attention. In this study, PDF was more serious in MHD patients with old age, dialytic vintage less than 36 months, poor control of IDWG, anemia, and inadequate dialysis.

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Author contributions
HL conceived of the study, and participated in its design and drafted the manuscript. JY carried out the investigation and data curation, participated in formal analysis and drafted the manuscript. YD carried out the investigation and data curation. ZT carried out the supervision and project administration, and participated in its design and coordination and helped to revise the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials
The data that support the findings of this study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
This study has been approved by the ethics committee of our hospital.

Consent for publication
All participants signed informed consent forms.

Competing interests
The authors declare no competing interests.

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References

1. Ali M, Ejaz A, Iram H, Solangi SA, Junejo AM, Solangi SA. Frequency of intradialytic complications in patients of end-stage renal disease on maintenance hemodialysis. Cureus. 2021;13(1):e12641.
2. Johansen KL. Life expectancy gains for patients with ESRD. Clin J Am Soc Nephrol. 2018;13(1):11–2.
3. Bossola M, Tazza L. Postdialysis fatigue: a frequent and debilitating symptom. Semin Dial. 2016;29(3):222–7.
4. Sklar AH, Riesenberg LA, Silber AK, Ahmed W, Ali A. Postdialysis fatigue. Am J Kidney Dis. 1996;28(5):732–6.
5. Bossola M, Di Stasio E, Monteburini T, et al. Intensity, duration, and frequency of post-dialysis fatigue in patients on chronic haemodialysis. J Ren Care. 2020;46(2):115–23.
6. Zu Y, Lu X, Yu Q, Yu L, Li H, Wang S. Higher postdialysis lactic acid is associated with postdialysis fatigue in maintenance of hemodialysis patients. Blood Purif. 2020;49(5):535–41.
7. Brys A, Stasio ED, Lenaert B, et al. Peridialytic serum cytokine levels and their relationship with postdialysis fatigue and recovery in patients on chronic haemodialysis - a preliminary study. Cytokine. 2020;135:155223.
8. Bossola M, Marzetti E, Di Stasio E, et al. Prevalence and associated variables of post-dialysis fatigue: results of a prospective multicentre study. Nephrology. 2018;23(6):552–8.
9. Rayner HC, Zepel L, Fuller DS, et al. Recovery time, quality of life, and mortality in hemodialysis patients: the dialysis outcomes and practice patterns study (DOPPS). Am J Kidney Dis. 2014;64(1):86–94.
10. Nair D, Finkelstein FO. Toward developing a patient-reported outcome measure for fatigue in hemodialysis. Am J Kidney Dis. 2019;74(2):151–4.
11. Ramer SJ, Scherer JS. Moving the science of patient-reported outcome measures forward: measuring fatigue in hemodialysis patients. Clin J Am Soc Nephrol. 2020;15(11):1546–8.
12. Horigan AE, Schneider SM, Docherty S, Barroso J. The experience and self-management of fatigue in patients on hemodialysis. Nephrol Nurs J. 2013;40(2):113–22.
13. Bossola M, Di Stasio E, Sirolli V, et al. Prevalence and severity of postdialysis fatigue are higher in patients on chronic hemodialysis with functional disability. Ther Apher Dial. 2018;22(6):635–40.
14. Gordon PL, Doyle JW, Johansen KL. Postdialysis fatigue is associated with sedentary behavior. Clin Nephrol. 2011;75(5):426–33.
15. Chen X. Blood purification standard operating procedure (SOP) 2010. Military Science Publishing House; 2010. (**in Chinese**).
16. CMDA. Clinical practice guidelines for adequacy of hemodialysis in China. Natl Med J China. 2015;95(34):2748–53 (**in Chinese**).
17. Lindsay RM, Heidenheim PA, Nesrallah G, Garg AX, Suri R, Daily Hemodialysis Study Group London Health Sciences C. Minutes to recovery after a hemodialysis session: a simple health-related quality of life question that is reliable, valid, and sensitive to change. Clin J Am Soc Nephrol. 2006;1(5):952–9.
18. Kodama H, Togari T, Konno Y, et al. A new assessment scale for post-dialysis fatigue in hemodialysis patients. Renal Replac Ther 2020;6(1).

19. Sklar A, Newman N, Scott R, Semenyuk L, Schultz J, Fiacco V. Identification of factors responsible for postdialysis fatigue. Am J Kidney Dis. 1999;34(3):464–70.
20. Joshwa B, Peters RM, Malek MH, Yarandi HN, Campbell ML. Multiple dimensions and correlates of fatigue in individuals on hemodialysis. Nephrol Nurs J May-Jun. 2020;47(3):215–51.
21. McIntyre CW, Burton JO, Selby NM, et al. Hemodialysis-induced cardiac dysfunction is associated with an acute reduction in global and segmental myocardial blood flow. Clin J Am Soc Nephrol. 2008;3(1):19–26.
22. Covic A, Siriopol D, Voroneanu L. Dialysis-induced segmental wall motion abnormalities, post-dialysis fatigue and cardiovascular mortality: the new Bermuda triangle? Nephrol Dial Transplant. 2013;28(10):2404–6.
23. Joshwa B, Peters R, Malek M, Yarandi H, Campbell M. Multiple dimensions and correlates of fatigue in individuals on hemodialysis. Nephrol Nurs J J Am Nephrol Nurs Assoc. 2020;47:215–51.

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