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# A Cross-Sectional Study on The Prevalence of Anemia in Maintenance Hemodialysis and Peritoneal Dialysis Patients and Its Related Factors

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**Abstract:** *Objective:* To study the prevalence of anemia, the proportion of hemoglobin (Hb) levels, the treatment methods, and the influencing factors of Hb levels in maintenance hemodialysis (MHD) and peritoneal dialysis patients. *Methods:* In this study, 602 patients with maintenance hemodialysis and continuous ambulatory peritoneal dialysis were enrolled from December 2020 to December 2022 in our hospital, and their medical records were collected and summarized. The main contents included the patient's gender, age, primary disease, dialysis duration, dialysis method, the use of erythropoietic stimulating agents (ESA), intravenous iron, and laboratory tests. A Hb index exceeding 110 g/L was set as the standard for the prevalence of anemia. *Results:* The rate of anemia in patients undergoing blood purification was 83%. The proportion of ESA use was 84.1%, and the proportion of iron use was 76.7%, of which the proportion of intravenous iron used was 17.0%, and the proportion of folic acid used was 28.3%. *Conclusion:* The incidence of anemia in MHD patients was relatively high, with a low proportion of patients reaching the standard Hb levels. Risk factors include albumin (ALB) levels, iron storage, white blood cells, C-reactive protein, cholesterol, etc. Nutritional support, iron supplementation, and prevention of micro-inflammatory reactions can effectively promote the improvement of Hb indicators in dialysis patients to prevent anemia.

**Keywords:** Hemodialysis; Peritoneal dialysis; Anemia; Related factors; Cross-sectional study

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## 1. Introduction

Anemia is a common complication of maintenance hemodialysis (MHD) and peritoneal dialysis patients [1], which can cause cardiovascular disease, affect the quality of life of patients, and increase mortality [2]. The application of comprehensive treatment and other methods to stabilize the hemoglobin (Hb) index of patients with end-stage renal disease (ESR can improve the patient's quality of life and reduce the mortality rate [3]. In

this study, we investigated and analyzed the prevalence of anemia in maintenance hemodialysis (MHD) and peritoneal dialysis patients, the treatment methods, and the related factors restricting Hb from reaching the standard levels.

## 2. Data and methods

### 2.1. General information

In this study, 602 patients who underwent MHD for more than 3 months in our hospital from December 2020 to December 2021 were selected, ranging from 13–88 years old, with an average age of 57.75 ± 13.15 years. There were 342 men and 260 women. Among them, 200 people suffered from diabetic nephropathy (DN). There were 344 patients with hypertensive nephropathy, 109 patients with chronic glomerulonephritis, and 11 patients with polycystic kidney disease.

### 2.2. Methods

Multicenter and cross-sectional methods were used to conduct the survey. The basic information of 602 patients and the relevant data from various examinations were collected.

### 2.3. Diagnostic criteria

According to the Kidney Disease Improving Global Outcomes (KDIGO) guidelines for renal anemia, the standard HB index for adult men is less than 130 g/L, whereas for adult women it is less than 120 g/L. The standard HB index for pregnant women is less than 10 g/L. A Hb index of more than 110 g/L was used as the standard for diagnosis of anemia.

### 2.4. Statistical methods

Statistical analysis was carried out using the SPSS 25.0 software. Measurement data were expressed as mean ± standard deviation, non-normal measurement data were expressed as M (P25, P75), and enumeration data were expressed as %. The Pearson correlation analysis was used if the data were normally distributed, otherwise, the Spearman rank correlation analysis was used. Multiple linear regression analysis was performed to observe the influencing factors of Hb levels. Results were considered statistically significant at $P < 0.05$.

## 3. Results

In this study, the mean concentration of Hb was 102.15 ± 27.3 g/L, and the number of patients with anemia was 341, accounting for 56.64% of the total. The number of patients who achieved the standard Hb index was 165 (29.20%) and the proportion of ESA use was 81.22%. One hundred and sixteen patients (19.26%) had ferritin levels above 500 g/L, transferrin saturation above 30% in 139 patients (23.08%), and the proportion of iron use was 30.39%. The comparison of demographic characteristics of hemodialysis patients is shown in **Table 1**. **Table 2** summarizes the linear regression analysis model on factors restricting the patient's Hb index from reaching the standard levels. The P-P chart of linear regression analysis is shown in **Figure 1**.

**Table 1.** Comparison of demographic characteristics of hemodialysis patients

| Parameter | Population ($n$ = 602) | Hb compliance group | Hb substandard group | $P$ |
|---|---|---|---|---|
| Age | 57.75 ± 13.15 | 57.29 ± 0.80 | 58.11 ± 0.75 | |
| Male [m (%)] | 342 (56.81) | 148 (43.27) | 194 (56.72) | |
| Chronic glomerulonephritis | 109 | 50 | 59 | |
| Diabetes | 200 | 43 | 157 | |
| Hypertension | 344 | 146 | 198 | |
| Polycystic kidney | 11 | 8 | 3 | |
| Dialysis type [m (%)] | | | | |
| Peritoneal dialysis | 96 (15.94) | 37 (38.54) | 59 (61.45) | |
| Hemodialysis | 506 (84.05) | 224 (44.26) | 282 (55.73) | |
| Laboratory indicators | | | | |
| Triglycerides | 2.01 (0.95, 2.54) | 2.31 (1.07, 2.96) | 1.79 (0.86, 2.06) | < 0.001 |
| Low-density lipoprotein | 2.22 (1.61, 2.73) | 2.34 (1.74, 2.77) | 2.13 (1.49, 2.72) | 0.007 |
| Ferritin | 329.73 (122.40, 429.48) | 267.54 (107.35, 329.73) | 377.84 (151.95, 496.95) | < 0.001 |
| Serum iron | 9.81 (6.97, 11.65) | 10.46 (7.82, 12.80) | 9.31 (6.28, 10.74) | < 0.001 |
| Transferrin saturation | 23.66 (15.56, 29.0) | 24.52 (17.15, 30.56) | 23.00 (13.75, 27.63) | 0.002 |
| Albumin | 39.44 (36.00, 42.20) | 41.34 (38.20, 43.35) | 37.99 (34.20, 41.05) | < 0.001 |
| White blood cells | 7.32 (5.06, 7.99) | 7.23 (5.54, 8.33) | 7.38 (4.78, 7.68) | < 0.001 |
| C-reactive protein | 14.99 (2.0, 14.99) | 9.66 (1.89, 11.32) | 19.06 (2.12, 16.80) | < 0.001 |
| Drug use rate | | | | |
| Iron | 100 | 83 (31.8) | 100 (100) | |
| Erythropoietin | 261 | 78 (94.0) | 96 (96) | |
| Folic acid | 26 | 7 (8.4) | 7 (7.0) | |

**Table 2.** Summary of linear regression analysis model on factors restricting patient's Hb index from reaching the standard

| Model | Unstandardized beta | Standardized coefficients beta | *t* | *P* |
|---|---|---|---|---|
| (Constant) | 69.12 | | 9.77 | < 0.001 |
| Age | 0.030 | 0.017 | 0.461 | 0.645 |
| Triglyceride | 1.35 | 0.107 | 2.84 | 0.005 |
| Low-density lipoprotein | 1.97 | 0.08 | 2.10 | 0.036 |
| Ferritin | -0.02 | -0.256 | -6.56 | < 0.001 |
| Saturation of transferrin | 0.23 | 0.14 | 2.19 | 0.029 |
| Serum iron | 0.186 | 0.039 | 0.619 | 0.536 |
| Albumin | 0.681 | 0.220 | 5.61 | < 0.001 |
| White blood cells | 0.006 | 0.003 | 0.075 | 0.940 |
| C-reactive protein | -0.082 | -0.103 | -2.651 | 0.008 |

Abbreviations: VIF, variance inflation factor

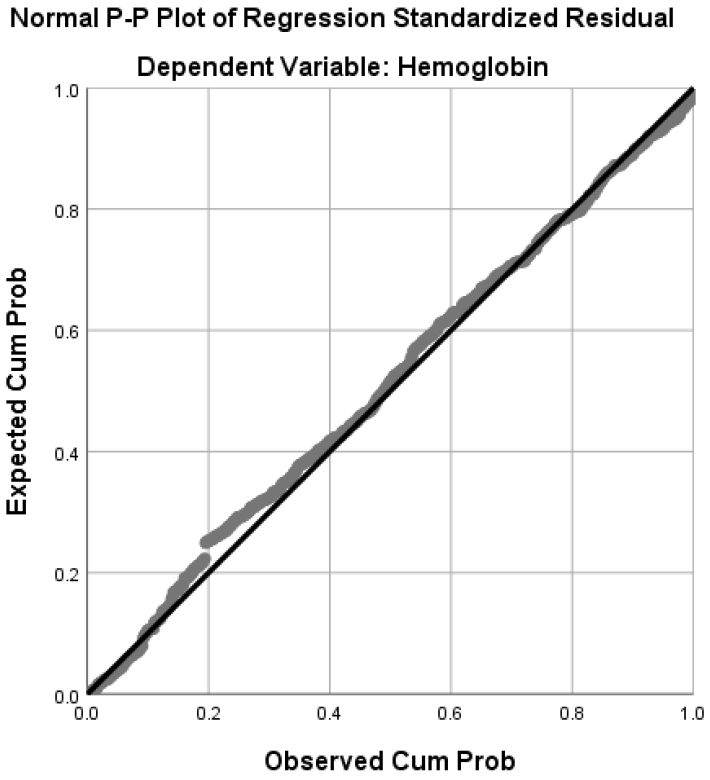


**Figure 1.** P-P chart of linear regression analysis of factors restricting patient's Hb index from reaching the standard

## 4. Discussion

The fitting degree of the linear regression model was adjusted to $r^2 = 0.171$, which meant that the independent variable could explain 17.1% of the change of the dependent variable, that is, the Hb index was affected by triglyceride, low-density lipoprotein, C-reactive protein, ferritin, albumin, and other factors. There were no significant differences in the age of patients in this study ($P > 0.05$).

In the coefficient table (**Table 2**), the independent variables included levels of triglyceride, low-density lipoprotein, albumin, ferritin, transferrin saturation, and C-reactive protein. These variables can significantly affect the patient's Hb index. Ferritin is the most reliable and sensitive index to assess iron storage and nutrition in the body and is an important basis for the diagnosis of iron deficiency anemia. Some data showed that patients with higher ferritin levels have a higher risk of cardiovascular diseases (CCVD) and infectious diseases than patients with lower ferritin levels, which may be the cause of anemia in this study [4]. Other studies showed that when iron deficiency occurs in patients, the progression of anemia worsens, hence iron supplementation is required.

However, this study is only an analysis of the result of the regression analysis. Continuous diagnosis of the regression model is needed to determine the accuracy, reliability, and credibility of the results.

(1) Diagnosis 1: The linear regression model requires the absence of multicollinearity between the independent variables as listed in **Table 2**. VIF less than 5 suggests that there is no multicollinearity between independent variables.

(2) Diagnosis 2: The residuals of the linear regression model obey the normal distribution. The P-P diagram of the residuals of the patient's regression model (**Figure 1**) indicates that the scatter points in the residuals are located on the diagonal line, obeying normal distribution.

(3) Diagnosis 3: The linear regression model requires no serial correlation between samples, but this diagnosis is only needed for time series data. The patient's Durbin Watson value was 0.375, which is far from a value of 2. Since the data is cross-sectional data, it was not considered.

Given the above diagnosis, it is suggested that the relationship between anemia indicators and their respective variables is accurate and reliable.

Anemia is a common complication of kidney disease and its incidence increases as the disease progresses. According to the recommendations of the Global Kidney Disease Outcome Improvement Organization (KDIGO), the target of anemia treatment for patients with ESRD is set at 115–130 g/L, and the target of anemia treatment for patients undergoing blood purification is set at 100–130 g/L by the Society of Nephrology. This study showed that the prevalence rate of anemia in this region was 83.9% and the rate of patients reaching the standard Hb index was 29.2%. This indicated that the treatment outcome of anemia in hemodialysis patients was not optimal and more interventions are required.

In the treatment of anemic patients, the basic concept of anemia should be fully understood. According to the data of this study, the prevalence of anemia in CKD patients was as high as 83%. In China, the treatment rate of CKD is low, where about 1/3 of CKD patients have not been effectively treated, and 1/3 of patients have lost their kidney function. Therefore, the prevention and treatment of anemia is a key factor in improving survival for CKD patients. At present, there are many methods to treat renal anemia, mainly the use of ESA [5], iron supplementation, and, to a lesser extent, blood transfusion [6].

According to the international and domestic treatment of anemia, for CKD anemic patients without iron or ESA treatment, the concentration of Hb did not increase [7]. Relevant data suggested that when the saturation level of transferrin (TSAT) was less than 30% and ferritin was less than 500 g/L, intravenous iron could be used for treatment. Regular maintenance of intravenous iron therapy can effectively reduce the mortality rate caused

by ESA but this method cannot enhance the Hb index to achieve the target rate of about 12 g per day. Hence, further studies are needed regarding anemia-causing factors. Yin et al. [8] investigated 1652 ESRD patients whose Hb levels were lower than the standard and analyzed the incidence of anemia in Liaoning Province. Patients complicated with infection, primary disease, red blood cell count, hematocrit (HCT), serum creatinine (Cr), serum calcium (Ca), and serum potassium (K) can affect the Hb levels. This finding was consistent with those in this study.

Renal anemia is not only related to the nutritional status of patients but also to the micro-inflammatory state (C-reactive protein), blood lipids (triglyceride, low-density lipoprotein), and other factors. Patients undergoing blood purification are prone to micro-inflammatory reactions due to a reduced clearance of inflammatory factors, increased infection of vascular access, biocompatibility of dialysis membrane, and other adverse factors, which inhibit the co-synthesis of erythropoietin, thus aggravating anemia [2]. Timely treatment of infection and improvement of dialysis techniques can alleviate the micro-inflammation of patients, thereby preventing anemia. This study suggests that by reducing the occurrence of chronic inflammation, improving nutritional status, and reducing the resistance of erythropoietin, anemia treatment can be improved.

## 5. Conclusion

The achievement of the standard Hb index in patients undergoing blood purification still needs to be improved. Dialysis duration, serum intact parathyroid hormone (iPTH), and albumin (ALB) may be the risk factors preventing ESRD patients from achieving the standard Hb index. Medical staff should pay attention to the treatment of anemia in dialysis patients in the later stages of the treatment to prevent the disease from worsening.

## Disclosure statement

The author declares no conflict of interest.

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