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Prevalence of Iron Deficiency and Anemia in Hemodialysis Patients with Chronic Kidney Disease and Its Relationship with Lipid Profile

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Abstract

Background: Chronic kidney disease is a growing global health issue, leading to high morbidity and mortality rates. Hemodialysis patients are particularly vulnerable to complications such as iron deficiency, anemia, and lipid profile abnormalities.

Objectives: This study aims to determine the prevalence of iron deficiency, anemia, and dyslipidemias and to explore the relationship between these conditions.

Material and Methods: We conducted an observational, descriptive, cross-sectional, prospective, and monocentric study at the Organ and Tissue Transplantation Department of Frantz Fanon Hospital in Blida, Algeria, from March to May 2024. Ferritin, hemoglobin, mean corpuscular volume, and a complete lipid profile were assessed for each patient.

Results: Sixty hemodialysis patients aged 18 and older were included in this study. The results indicate that 30% of patients suffer from iron deficiency, while 81.7% have anemia. Regarding the lipid profile, 65% of participants have dyslipidemia, with hypertriglyceridemia (35.9%) and hyper-LDL-cholesterol (23.1%) being the most common. Spearman correlation analyses show a significant inverse relationship between ferritin levels and total cholesterol concentrations ($R = -0.417$, $p<0.05$), triglycerides ($R = -0.365$, $p <0.05$), and LDL-cholesterol ($R = -0.48$, $p <0.05$). However, no significant correlation was found between ferritin and HDL-cholesterol ($R = 0.234$, $p>0.05$).

Conclusions: These results highlight the need for integrated and personalized clinical management for hemodialysis patients. Appropriate nutritional interventions and regular monitoring are crucial to optimizing clinical outcomes and improving the quality of life for these patients.

Keywords: Chronic kidney disease; iron deficiency; anemia; dyslipidemia; correlation

Abbreviations

CKD: Chronic kidney disease, MCV: Mean Corpuscular Volume, Hb: Hemoglobin, TC: Total Cholesterol, TG: Triglycerides, HDL-C: High-Density Lipoprotein, LDL-C: Low-Density Lipoprotein Cholesterol.

Introduction

Chronic kidney disease (CKD) represents an ever-increasing global health burden, resulting in high morbidity and significant mortality. It is estimated that approximately 2.6 million patients worldwide are currently undergoing dialysis treatment [1]. Among the therapeutic options available for this debilitating condition, hemodialysis remains an essential method for temporarily addressing advanced renal insufficiency. However, patients undergoing hemodialysis face a range of severe complications, with iron deficiency, anemia, and lipid profile disturbances standing out due to their high prevalence and profound clinical implications.

The kidney plays a vital role in human metabolism, not only by efficiently eliminating metabolic waste products such as urea, uric acid, and creatinine but also by performing crucial endocrine functions [2]. It synthesizes essential hormones such as renin, which regulates blood pressure, and erythropoietin, which stimulates red blood cell production in the body. This dual function underscores the kidney's critical importance in maintaining bodily homeostasis and regulating metabolic functions [3]. Through its blood filtration process, the kidney plays a key role in eliminating waste products such as urea, uric acid, and creatinine [4]. It also performs an endocrine function, which involves the synthesis of renin and erythropoietin two essential hormones responsible for blood pressure regulation and the production of red blood cells in the body [3]. In patients with CKD, particularly those undergoing hemodialysis, these critical functions are severely impaired, leading to profound metabolic disturbances that exacerbate morbidity and the complexity of their health condition [5]. Iron deficiency and anemia are common complications in hemodialysis patients, often resulting from repeated blood losses during dialysis sessions and reduced intestinal absorption [6]. Lipid profile abnormalities are also frequently observed in these patients, further complicating their medical management [7]. The effective management of iron deficiency, anemia, and lipid profile abnormalities in these patients represents a major clinical challenge, requiring a thorough understanding of the underlying pathophysiological mechanisms and a tailored therapeutic approach.

The objectives of our study are multifaceted:

- To determine the prevalence of iron deficiency and anemia among hemodialysis patients.
- To analyze the lipid profiles of hemodialysis patients and identify the most common types of dyslipidemia.
- To investigate the relationship between iron deficiency, anemia, and lipid profile abnormalities by exploring correlations and interactions among these conditions.

This study aims to deepen our understanding of the underlying mechanisms of these complications in hemodialysis patients and to develop tailored therapeutic and preventive strategies to optimize their clinical management.

Materials and Methods

Type, Period, and Location of the Study

This is an observational, descriptive, cross-sectional, prospective, and monocentric study conducted at the Organ and Tissue Transplantation (TOT) Department of Frantz Fanon Hospital, located in the Blida region of Algeria. The study was carried out over a three-month period, from March to May 2024.

Inclusion and Exclusion Criteria

Inclusion Criteria

- Patients aged 18 years and older.
- Patients diagnosed with chronic kidney disease requiring hemodialysis sessions.
- Patients capable of providing informed consent to participate in the study.

Exclusion Criteria

- Patients with severe medical conditions other than chronic kidney disease and iron-deficiency anemia.
- Patients unable to complete the questionnaire or actively participate in the study.
- Patients refusing to participate or not providing informed consent.

Ethical Considerations

This study was approved by the Ethics Committee of Frantz Fanon Hospital, Blida, Algeria. The ethical principles outlined in the Declaration of Helsinki were strictly adhered to throughout the research process. Absolute confidentiality of participants' personal data was ensured, and informed consent was obtained prior to their inclusion in the study. Participants were thoroughly informed about the nature of the study, their rights to confidentiality and data protection, as well as their freedom to withdraw from the study at any time without any impact on their medical treatment.

Data Collection

Data were collected using a structured questionnaire. It included several sections designed to gather demographic and clinical information, details on symptoms of iron deficiency and anemia, lipid profiles, and the lifestyle of hemodialysis patients.

Biological Assays

To assess the biological parameters of the participants, the following assays were performed:

- ***Ferritin***: Measurement of serum ferritin concentration, an indicator of the body's iron stores.
- ***Mean Corpuscular Volume (MCV):*** Measurement of the average volume of red blood cells, commonly used to diagnose and monitor anemias.
- ***Hemoglobin (Hb):*** Measurement of hemoglobin concentration in the blood, essential for evaluating oxygen transport capacity.
- ***Lipid Profile:*** Including the measurement of total cholesterol, triglycerides, HDL cholesterol, and LDL cholesterol, to assess the participants' lipid profile.

Statistical Analysis

The statistical analysis was performed using the "SPSS 21.0" software, with a significance level set at 5% for all analyses. Descriptive analysis presented qualitative variables in terms of frequencies and valid percentages, while quantitative data were characterized by their mean, standard deviation, and respective minimum and maximum values. Proportion comparisons were conducted using the Chi-square test. To evaluate correlations between variables such as ferritin, hemoglobin, MCV, and lipid parameters, the Spearman correlation coefficient test was chosen due to the non-normal distribution of the data ($p < 0.05$).

Results

Population Characteristics

In this study, the distribution of hemodialysis patients by sex shows a slight female predominance, with 53.3% women (32 patients) and 46.7% men (28 patients), out of a total of 60 participants. The female-to-male ratio is 1.14. The average age of our population is 42 ± 16.55 years. The mean BMI is 24.09 ± 3.44 kg/m^2. The majority of participants (80%) undergo two hemodialysis sessions per week. The distribution of hemodialysis patients by blood group demonstrates diversity among the 60 participants. Blood group B+ is the most common, representing 33.3% (20 patients), followed by O+ at 31.7% (19 patients) and A+ at 23.3% (14 patients). Negative blood groups are less frequent: B- accounts for 6.7% (4 patients), A- for 3.3% (2 patients), and O- for 1.7% (1 patient). Among the hemodialysis patients, 55% (33 patients) have kidney disease as their sole condition, while diabetes, hypertension, and cardiovascular diseases are each present in 15% (9 patients) of the studied sample.

Prevalence of Iron Deficiency, Anemia, and Dyslipidemia

The distribution of hemodialysis patients based on ferritin status reveals that 70% have normal iron levels, while 30% exhibit iron deficiency. Regarding hemoglobin levels, 18.3% of patients have normal levels, whereas 81.7% suffer from anemia (Table 1).

	Normal	***Abnormal***	***P***
Ferritin status	42 (70%)	18 (30%)	0.02
Hb status	11 (18,3%)	49 (81,7%)	<0.05
Lipid profile	21 (35%)	39 (65%)	0.02
Note: The P-value is obtained using the chi-square test.			

Table 1: Distribution of patients according to ferritin status, hemoglobin (Hb) status, and lipid profile.

A significant difference is observed between anemic patients and those with normal hemoglobin levels across blood groups. For instance, among anemic patients, blood group O+ is the most represented (18 patients), followed closely by groups B+ (15 patients) and A+ (13 patients). These findings suggest a potentially significant correlation between blood group and the prevalence of anemia among hemodialysis patients ($p = 0.008$).

Lipid Profile of Hemodialysis Patients

Regarding the lipid profile of hemodialysis patients, 65% present with dyslipidemia, while 35% have a normal lipid profile. Among the 39 patients with dyslipidemia, hypertriglyceridemia is the most frequent abnormality, affecting 35.9% of cases (14 patients). This is followed by hyper-LDL-cholesterolemia, observed in 23.1% of patients (9 patients).

Relationship Between Anemia, Iron Deficiency, and Lipid Profile

Spearman's correlation results reveal a significant negative correlation between ferritin levels and total cholesterol in hemodialysis patients ($R = -0.41$; $p < 0.05$). Additionally, a significant negative correlation was observed between ferritin levels and triglycerides ($R = -0.36$; $p < 0.05$), as well as between ferritin levels and LDL-cholesterol ($R = -0.48$; $p < 0.05$). In contrast, no significant correlation was found between ferritin levels and HDL-cholesterol ($R = 0.23$; $p > 0.05$).

Hemoglobin and Mean Corpuscular Volume Relationships with Lipid Profile

Hemoglobin levels show a non-significant positive correlation with total cholesterol and HDL-cholesterol, while a negative trend is observed with LDL-cholesterol. However, these associations are not statistically significant.

The mean corpuscular volume (MCV) demonstrates a significant negative correlation with total cholesterol, suggesting a possible inverse relationship between red blood cell size and total cholesterol levels. Conversely, the correlations between MCV and triglycerides, HDL-cholesterol, as well as LDL-cholesterol, are weak and not statistically significant (Table 2).

	R	***P***
Ferritin/(TC)	-0,41	<0.05
Ferritin/TG	-0,36	<0.05
Ferritin/HDL- C	0.23	<0.05
Ferritin/LDL-C	-0,48	<0.05
Hb/TC	0.11	<0.05
Hb/TG	- 0.23	<0.05
Hb/HDL-C	0.22	<0.05

Hb/LDL-C	- 0.34	<0.05
MCV/TC	- 0.32	<0.05
MCV/TG	- 0.21	<0.05
MCV/HDL-C	0.17	<0.05
MCV/LDL-C	- 0.32	<0.05

Table 2: Spearman Correlations Between the Different Parameters Studied.

Discussion

Our study has yielded several findings regarding dyslipidemia, iron deficiency, and anemia in patients with chronic kidney disease, as well as their relationship with lipid profiles. In our study, the gender distribution shows a slight female predominance, with 53.3% women and 46.7% men. This distribution contrasts with the findings of Bishaw et al. in Ethiopia, where a male predominance was reported (64.67% men) [8].

Regarding the prevalence of chronic kidney disease by gender, studies have shown that CKD appears to have a higher prevalence in women compared to men [9, 10]. A review encompassing a large number of studies revealed that 38 studies reported a higher prevalence of CKD in women, while 13 studies found a higher prevalence in men. These differences may be influenced by hormonal, behavioral, and genetic factors, as well as acess to healthcare and clinical practices [11]. In our study, 55% of hemodialysis patients had kidney disease as their sole pathology, while diabetes, hypertension, and cardiovascular diseases were each present in 15% of the patients. Comparatively, the study by Bishaw et al. revealed that hypertension (40.7%) and diabetes (14.7%) were common causes of CKD [8].

The average age of hemodialysis patients in our study was 42 years, making it relevant to specifically explore the impact of chronic kidney disease in younger adults. This population exhibits distinct characteristics that influence their experience with CKD and their response to hemodialysis treatment. Young adults with CKD often face unique challenges affecting their quality of life, education, and professional and family aspirations. Unlike older patients, they are generally more physically and socially active, making disease management more complex and demanding [12]. The underlying causes of CKD in young adults may differ from those in older individuals. Factors such as glomerular diseases, autoimmune disorders, and hereditary conditions often play a significant role in this population. Furthermore, young adults are at a higher risk of rapid progression to end-stage renal disease, necessitating heightened vigilance and early diagnosis [13].

The prevalence of anemia in our study is 81.7%, which is similar to that reported by Garrido et al. (2019), who found a prevalence of 80.22% in Ecuador [14]. This high prevalence of anemia is a well-documented characteristic of patients undergoing hemodialysis. Anemia is common in patients with chronic kidney disease primarily due to the reduced production of erythropoietin by damaged kidneys [15]. Erythropoietin is an essential hormone for the production of red blood cells in the bone marrow. When kidney function declines, erythropoietin production decreases, leading to a reduction in red blood cell production and, consequently, anemia [16]. Additionally, hemodialysis patients often experience frequent blood losses during dialysis sessions and deficiencies in essential nutrients such as iron, vitamin B12, and folic acid, which are critical for red blood cell production. These combined factors contribute to the high prevalence of anemia observed in this population [17].

Our study shows iron deficiency in 30% of patients, a figure comparable to the 33.21% reported by Garrido et al. Conversely, Choukroun et al. reported a higher prevalence of iron deficiency (47.1%) among non-dialyzed CKD patients in France [18], while Amjad et al. found a prevalence of 24.2% in hemodialysis patients in Pakistan [19].

Among the anemic patients in our study, 50% suffer from microcytic anemia and 31.7% from macrocytic anemia. In comparison, Garrido et al. (2019) reported a lower frequency of microcytosis [14]. Wojtaszek et al. (2020) emphasized that although anemia and iron deficiency are often interconnected, they are distinct clinical entities in the context of CKD. This distinction is crucial for clinical management, requiring specific therapeutic approaches for each condition [20]. Gutiérrez demonstrated that iron deficiency plays a critical role in the development of anemia in CKD patients, which supports our findings. These observations highlight the importance of integrated management of iron levels to prevent anemia in hemodialysis patients [21].

Our study reveals a significant difference in the distribution of patients with anemia compared to those with normal hemoglobin levels based on different blood groups. The current literature on the relationship between blood groups and the prevalence of anemia in dialysis patients is limited. However, a retrospective study examined blood groups according to the ABO system in 1162 men aged 18 to 65, classified as anemic or healthy based on their hemoglobin concentrations. The results of this study show that the most common blood group among anemic individuals was A Rh(+) with 41%, followed by O Rh(+) with 26%, while the least common group was AB Rh(-) with 0.5% [22]. These observations partly corroborate our findings, where we also found that the O+ blood group was the most represented among anemic patients. Although this relationship warrants further investigation, it may suggest physiological or genetic differences associated with blood groups, influencing the predisposition to anemia in dialysis patients. Future research would be needed to explore these links and better understand the underlying mechanisms. Our study revealed a 65% prevalence of dyslipidemia among dialysis patients. Dyslipidemia is frequently observed in dialysis patients [23]. While the specific types of lipid abnormalities vary between studies, for example, Hasan et al. found that the most common dyslipidemia in dialysis patients in Syria was hypo-HDL-cholesterolemia (72.5%), followed by hypertriglyceridemia (37.3%)[1]. In contrast, our study revealed that hypertriglyceridemia was the most common (35.9%), followed by hyper-LDL-cholesterolemia (23.1%).

These differences in lipid profile abnormalities could be attributed to factors such as geographical variations, dietary habits, genetic differences, or the specific dialysis protocols used. Further research is needed to explore these factors in more depth and to standardize diagnostic criteria for dyslipidemia in this population. The high prevalence of dyslipidemia in dialysis patients can be explained by several interconnected factors. Firstly, chronic kidney disease disrupts lipid metabolism in several ways. Damaged kidneys are less effective at eliminating cholesterol and triglycerides, leading to lipid accumulation in the blood. Additionally, reduced clearance of high-density lipoproteins and decreased synthesis of low-density lipoproteins contribute to altered lipid profiles [24]. The literature also shows that dialysis patients often have comorbidities such as diabetes and hypertension, which themselves are risk factors for dyslipidemia [25]. Finally, specific dietary practices recommended for dialysis patients may influence lipid profiles, often characterized by sodium and potassium restrictions, as well as the use of cholesterol absorption inhibitors [26]. To discuss the relationship between dyslipidemia, anemia, and iron deficiency in dialysis patients, it is important to note that studies examining this relationship are relatively limited. Our results show significant correlations between ferritin concentration and various lipid parameters, including a negative correlation with total cholesterol, triglycerides, and LDL-cholesterol, as well as a non-significant correlation with HDL-cholesterol. These observations suggest a complex influence of ferritin on the lipid profile of dialysis patients. The study conducted by Patel and Priya (2024) at the Paramedical and Health Sciences Institute, Parul University, Vadodara, Gujarat, India, between December 2022 and May 2023, included 100 patients with iron-deficiency anemia aged 25 to 45 years. This study found that, when observed for dyslipidemia, patients with iron-deficiency anemia had significantly lower levels of total cholesterol, triglycerides, and HDL-cholesterol compared to their serum iron levels [27]. The study by Gharib et al. conducted in Egypt also revealed an association between iron-deficiency anemia and dyslipidemia, showing significantly elevated levels of triglycerides, total cholesterol, and LDL-cholesterol in anemic patients compared to healthy controls. This association could be explained by the effects of anemia on lipid metabolism, where iron deficiency may negatively influence lipid regulation, thus promoting unfavorable lipid profiles [28].

Limitations and Challenges of the Study

The small sample size, comprising 32 women and 28 men, represents a significant limitation of our study. Furthermore, interactions with patients were restricted due to post-dialysis fatigue and early treatment schedules, which sometimes hindered the completion of necessary interviews. These conditions affected the quality and completeness of the data collected, despite our efforts to minimize these impacts by adapting our data collection methods.

Conclusion

In conclusion, the effective management of iron deficiency, anemia, and lipid profile abnormalities in hemodialysis patients represents a major clinical challenge. Our findings emphasize the importance of an integrated and personalized approach, including tailored nutritional interventions and regular monitoring to optimize clinical outcomes and improve the quality of life for these vulnerable patients.

For the future, it is crucial to continue research in the following areas:

- ***Longitudinal studies***: Evaluate the long-term effectiveness of nutritional and pharmacological interventions on clinical outcomes and the quality of life of hemodialysis patients.
- ***Therapeutic innovations***: Explore new therapeutic strategies, including enhanced iron supplementation agents and innovative lipid therapies tailored to the specific needs of hemodialysis patients.
- ***Education and training***: Develop educational programs for healthcare professionals on the optimal management of chronic kidney disease in young adults, focusing on the integration of nutritional and clinical recommendations into daily practice.

Conflict of interest

The authors declare that they have no conflicts of interest related to this article.

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