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Inflammatory Syndrome and Malnutrition in Chronic Hemodialysis Patients in Brazzaville: Prevalence and Factors Associated with Hypoalbuminemia

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Abstract

Background: Chronic kidney disease and its terminal stage represent a growing global health burden, particularly in sub-Saharan Africa where access to optimal renal replacement therapy remains limited. Among hemodialysis patients, chronic inflammation and protein-energy wasting are major determinants of poor outcomes and are closely interrelated within the Malnutrition-Inflammation-Atherosclerosis (MIA) syndrome. However, data from Central Africa remain scarce. **Objective:** To assess the prevalence of hypoalbuminemia and inflammatory syndrome, and to identify factors independently associated with hypoalbuminemia in chronic hemodialysis patients in Brazzaville. **Methods:** We conducted a cross-sectional analytical study including adult patients undergoing chronic hemodialysis in two public dialysis centers in Brazzaville between March and December 2025. Hypoalbuminemia was defined as serum albumin < 35 g/L and inflammatory syndrome as C-reactive protein (CRP) > 6 mg/L. Multivariate logistic regression was performed to identify factors independently associated with hypoalbuminemia. **Results:** A total of 60 patients were included (mean age: 53.0 ± 12.1 years; 70% male). The prevalence of hypoalbuminemia was 26.7%, while inflammatory syndrome was observed in 56.7% of patients. Hypoalbuminemia was associated with longer dialysis duration (p = 0.013), elevated CRP levels (p = 0.049), and inflammatory syndrome (p = 0.007). In multivariate analysis, inflammatory syn-

drome (adjusted OR = 9.97; 95% CI: 1.75 - 56.75; p = 0.010) and diabetes mellitus (adjusted OR = 4.81; 95% CI: 1.05 - 21.95; p = 0.043) were independently associated with hypoalbuminemia. **Conclusion**: Hypoalbuminemia is frequent among chronic hemodialysis patients in Brazzaville and is strongly associated with persistent systemic inflammation. These findings highlight the central role of the MIA syndrome and the need for integrated management strategies targeting both inflammation and nutritional status to improve patient outcomes.

Keywords

Inflammation, Malnutrition, Chronic Hemodialysis, Congo

1. Introduction

End-stage renal disease represents a major public health concern worldwide, with a growing prevalence in sub-Saharan Africa [1] [2]. Hemodialysis remains the main renal replacement therapy in our setting, but it is associated with numerous metabolic and nutritional complications [3].

Among these, protein-energy wasting and inflammatory syndrome play a central role. Their interaction constitutes the foundation of the Malnutrition-Inflammation-Atherosclerosis (MIA) syndrome, which is recognized as a major determinant of morbidity and mortality in hemodialysis patients [4] [5].

Hypoalbuminemia, an indirect marker of both malnutrition and inflammation, is strongly associated with an increased risk of cardiovascular complications, infections, and mortality [6] [7]. In resource-limited settings, particularly in Central Africa, the factors contributing to hypoalbuminemia remain insufficiently documented [8] [9].

In Brazzaville, few studies have analytically explored the relationships between inflammation, malnutrition, and dialysis-related parameters. A better understanding of these interactions could help optimize the management of hemodialysis patients and improve their prognosis, which underlines the rationale for this study.

2. Methodology

2.1. Study Design and Setting

We conducted a cross-sectional analytical study based on data routinely collected from chronic hemodialysis patients.

The study was carried out in two public hemodialysis centers in Brazzaville: the Renal Failure Treatment Center (CTIR) and the hemodialysis unit of the National Sickle Cell Disease Reference Center (CNRD).

Data were collected over an 8-month period from March to December 2025.

2.2. Study Population

The study population consisted of adult patients undergoing chronic hemodialy-

sis who were followed in the hemodialysis center where the study was conducted.

2.3. Inclusion Criteria

We included patients aged at least 18 years; on chronic hemodialysis for at least 3 months; with available biological data including serum albumin and C-reactive protein (CRP); receiving regular follow-up with weekly hemodialysis sessions; and who had provided their consent to participate in the study.

2.4. Exclusion Criteria

Patients with chronic hemodialysis presenting with acute infection, active inflammatory disease, or recent hospitalization at the time of inclusion were excluded. These conditions were identified through clinical examination, review of medical records, recent hospitalization reports, ongoing antibiotic therapy, fever, or documented inflammatory or infectious conditions in the patients' charts.

2.5. Data Collection

Data were extracted from patients' medical records; the hemodialysis unit register; and the hemodialysis session follow-up notebooks.

A standardized data collection form was used.

Blood samples for serum albumin and CRP measurements were collected before the midweek hemodialysis session in order to minimize the influence of dialysis-induced fluid shifts. Serum albumin was measured using the bromocresol green method, while CRP was determined by immunoturbidimetric assay using the Mindray BS-240 automated biochemistry analyzer routinely used in the participating centers.

2.6. Study Variables

The main outcome variable (dependent variable) was hypoalbuminemia, defined as serum albumin < 35 g/L.

The main explanatory variable was inflammatory syndrome, defined as CRP > 6 mg/L.

Other explanatory variables included sociodemographic variables (age in years, sex, socioeconomic status), clinical variables (hypertension, diabetes, cardiovascular disease, duration on hemodialysis, residual diuresis), dialysis-related variables (achievement of dry weight and KT/V index, with adequate dialysis defined as KT/V ≥ 1.2), and biological variables (CRP in mg/L, serum albumin, serum creatinine, hemoglobin in g/dL, with a level < 11 g/dL defined as anemia).

2.7. Statistical Analysis

Statistical analyses were performed using R software.

Quantitative variables were expressed as mean ± standard deviation or as median (interquartile range) depending on their distribution. Normality of quantitative variables was assessed using the Shapiro-Wilk test. Variables with non-nor-

mal distribution were expressed as median and interquartile range (IQR) and compared using the Mann-Whitney U test. Qualitative variables were presented as counts and percentages. Patients were divided into two groups according to the presence or absence of hypoalbuminemia.

Comparisons were performed using the Chi-square test (or Fisher's exact test) for qualitative variables. Student's t-test was used for normally distributed quantitative variables, whereas the Mann-Whitney U test was used for variables with non-normal distribution.

Binary logistic regression was used to identify factors independently associated with hypoalbuminemia.

Inflammatory syndrome was entered into the multivariable model as a categorical variable rather than continuous CRP values in order to improve clinical interpretability and avoid instability related to the skewed distribution of CRP levels. Collinearity between inflammatory syndrome and continuous CRP was considered, and both variables were not simultaneously included in the same multivariable model.

Variables with a p-value < 0.20 in bivariate analysis were included in the multivariate model. Results were expressed as Odds Ratios (OR) with a 95% confidence interval (95% CI) and a p-value, with the level of statistical significance set at $p < 0.05$.

2.8. Ethical Considerations

The study was conducted in accordance with the principles of the Declaration of Helsinki.

2.9. Flow of Patient Selection

A total of 120 chronic hemodialysis patients were screened for eligibility during the study period. Six patients died before inclusion, and 54 patients were not included because they did not meet the eligibility criteria or had incomplete biological data, particularly missing serum albumin or CRP measurements. Finally, 60 patients met the inclusion criteria and were included in the final analysis.

3. Results

3.1. General Characteristics of the Population

A total of 60 chronic hemodialysis patients were included in the study. The mean age of the patients was 53.0 ± 12.1 years. The population was predominantly male with 42 men (70%) and 18 women (30%). Hypertension was present in 96.7% of patients, while diabetes was found in 28.3%.

The detailed baseline characteristics of the study population are presented in Table 1.

Most patients belonged to the 45 - 59 years age group (43.3%). Median dialysis duration was 6 months [IQR: 4.8 - 17.2], and 68.3% of patients still had residual diuresis. The median weekly Kt/V was 1.1 [1.0 - 1.2], indicating that a large

Table 1. General characteristics of the study population (N = 60).

Variable	Value
Age (years)	
Mean	53.0 ± 12.1
20 - 44	13 (21.7)
45 - 59	26 (43.3)
60 - 74	20 (33.3)
≥75	1 (1.7)
Sex**	
Male	42 (70.0)
Female	18 (30.0)
Socioeconomic status**	
Low	9 (15.0)
Middle	34 (56.7)
High	17 (28.3)
Hypertension**	58 (96.7)
Diabetes mellitus**	17 (28.3)
Cardiovascular disease**	36 (60.0)
Dialysis duration (months)***	6.0 [4.8 - 17.2]
Residual diuresis**	41 (68.3)
Weekly Kt/V***	1.1 [1.0 - 1.2]
Hemoglobin (g/dL)*	8.9 ± 1.7
BMI (kg/m^2)***	22.9 [20.9 - 24.6]
Serum albumin (g/L)*	38.1 ± 5.1
Serum creatinine (µmol/L)*	892.2 ± 309.3
CRP (mg/L)***	7.5 [1.9 - 21.0]

*Mean ± SD; **n (%); ***Median [IQR]; BMI: Body Mass Index.

proportion of patients did not achieve optimal dialysis adequacy.

3.2. Prevalence of Hypoalbuminemia and Inflammatory Syndrome

Hypoalbuminemia was found in 16 patients, corresponding to a prevalence of 26.7%.

Inflammatory syndrome was found in 34 patients, corresponding to a prevalence of 56.7%.

3.3. Factors Associated with Hypoalbuminemia

Patients with hypoalbuminemia had a significantly higher CRP than those with-

out hypoalbuminemia. The results of the bivariate analysis of factors associated with hypoalbuminemia are summarized in Table 2.

Patients with hypoalbuminemia had a longer median dialysis duration than those without hypoalbuminemia (13.0 vs. 5.0 months, p = 0.013). Inflammatory syndrome was markedly more frequent in the hypoalbuminemia group (87.5% vs. 45.5%, p = 0.007). Diabetes mellitus also tended to be more common among patients with hypoalbuminemia (50.0% vs. 20.5%, p = 0.05).

In multivariable analysis, inflammatory syndrome remained strongly associated with hypoalbuminemia despite the relatively wide confidence interval (adjusted OR = 9.97; 95% CI: 1.75 - 56.75). Diabetes mellitus was also independently associated with hypoalbuminemia (adjusted OR = 4.81; 95% CI: 1.05 - 21.95). The multivariable logistic regression analysis is presented in Table 3.

Table 2. Bivariate analysis of factors associated with hypoalbuminemia (N = 60).

Variable	Normal albumin (n = 44)	Hypoalbuminemia (n = 16)	p-value	Crude OR [95% CI]
Age (years)	52.6 ± 11.8	54.2 ± 13.0	0.675	—
Male sex	31 (70.5)	11 (68.8)	1.000	0.92 [0.27 - 3.14]
Low SES	6 (13.6)	3 (18.8)	0.689	1.46 [0.32 - 6.61]
Hypertension	43 (97.7)	15 (93.8)	0.466	0.35 [0.03 - 3.64]
Diabetes mellitus	9 (20.5)	8 (50.0)	0.055	3.89 [1.14 - 13.22]
Cardiovascular disease	27 (61.4)	9 (56.2)	1.000	0.81 [0.25 - 2.64]
Dialysis duration (months)	5.0 [4.0 - 10.2]	13.0 [5.0 - 44.5]	0.013	—
Residual diuresis	30 (68.2)	11 (68.8)	1.000	1.03 [0.30 - 3.56]
Dry weight achieved	19 (43.2)	9 (56.2)	0.545	1.69 [0.54 - 5.29]
Inadequate dialysis	31 (70.5)	12 (75.0)	1.000	1.26 [0.34 - 4.61]
Anemia	39 (88.6)	15 (93.8)	1.000	1.92 [0.21 - 17.3]
BMI (kg/m^2)	23.2 [21.1 - 25.0]	21.5 [19.8 - 23.6]	0.110	—
Inflammatory syndrome	20 (45.5)	14 (87.5)	0.007	8.40 [1.70 - 41.44]

BMI = Body Mass Index; SES = Socioeconomic Status.

Table 3. Multivariable logistic regression analysis of factors associated with hypoalbuminemia (N = 60).

Variable	Normal albumin (n = 44)	Hypoalbuminemia (n = 16)	Adjusted OR [95% CI]	p-value
Inflammatory syndrome	20 (45.5)	14 (87.5)	9.97 [1.75 - 56.75]	0.010
Diabetes mellitus	9 (20.5)	8 (50.0)	4.81 [1.05 - 21.95]	0.043
Dialysis duration (months)	5.0 [4.0 - 10.2]	13.0 [5.0 - 44.5]	0.97 [0.92 - 1.03]	0.343
BMI (kg/m^2)	23.2 [21.1 - 25.0]	21.5 [19.8 - 23.6]	0.86 [0.69 - 1.08]	0.199

BMI = Body Mass Index.

4. Discussion

In this study conducted among chronic hemodialysis patients in Congo, we highlight a high prevalence of hypoalbuminemia and inflammatory syndrome, as well as an independent and robust association between systemic inflammation and malnutrition. These results provide original data in Central Africa and fit within the conceptual framework of the MIA syndrome (Malnutrition-Inflammation-Atherosclerosis) [4].

4.1. Hypoalbuminemia

The prevalence of hypoalbuminemia observed (26.7%) is intermediate compared to international data. In large Western cohorts, it is generally reported between 15 and 25% [5] [6], whereas in African or resource-limited settings, it can reach 30 to 50% [9] [10]. This variability reflects the deeply multifactorial nature of albumin, which does not constitute a simple nutritional marker, but an integrative biomarker influenced by: inflammatory status, protein losses, hydration status, and liver function [7]. Thus, our results confirm that hypoalbuminemia should be interpreted as a global risk marker, and not as an isolated indicator of malnutrition.

4.2. Inflammatory Syndrome

The high prevalence of inflammatory syndrome (56.7%) observed in our study is consistent with data from the literature, which describe chronic inflammation in nearly 40% to 60% of hemodialysis patients [7] [11]. This inflammation is now considered a central biological signature of hemodialysis, resulting from the interaction of several mechanisms: activation of the innate immune system by dialysis membranes, exposure to endotoxins related to water quality, micro-inflammation related to vascular access, accumulation of pro-inflammatory uremic toxins, and metabolic comorbidities (diabetes, atherosclerosis) [3].

In resource-limited settings, these phenomena may be amplified by: variable dialysate quality, limited access to biocompatible membranes, and less frequent biological monitoring [12].

4.3. Association between Inflammatory Syndrome and Hypoalbuminemia

The main finding of our study is the strong association between inflammatory syndrome and hypoalbuminemia (adjusted OR ≈ 10), confirming a strong link between inflammation and malnutrition. This result is fully consistent with the seminal work of Kalantar-Zadeh *et al.*, who introduced the concept of malnutrition-inflammation complex syndrome (MICS) [5], and that of Stenvinkel *et al.*, who expanded this model to the MIA syndrome [4].

From a mechanistic point of view, several pathways explain this relationship: pro-inflammatory cytokines, particularly IL-6, induce a shift in hepatic synthesis toward acute-phase proteins (CRP, fibrinogen) at the expense of albumin; inflammation activates the ubiquitin-proteasome system, leading to accelerated degra-

dation of muscle proteins; and increased capillary permeability promotes extravascular losses of albumin [13].

Thus, hypoalbuminemia appears as a biological phenotype of chronic inflammation, which explains the strength of the association observed in our study.

Nevertheless, the wide confidence intervals observed in the multivariable analysis suggest limited precision of the estimates, likely related to the relatively small sample size.

4.4. Role of Diabetes: Metabolic and Inflammatory Interaction

The independent association between diabetes and hypoalbuminemia observed in our study is consistent with the literature [12] [14]. Diabetes contributes to malnutrition through several mechanisms: chronic low-grade inflammation, insulin resistance promoting protein catabolism, vascular complications impairing tissue perfusion, and anorexia related to digestive complications [3]. This interaction reinforces the concept that diabetic hemodialysis patients represent a high-risk nutritional and inflammatory phenotype.

4.5. Dialysis Duration: An Indirect Marker

The association observed in bivariate analysis between dialysis duration and hypoalbuminemia, not confirmed in multivariate analysis, suggests an indirect effect. This result is consistent with previous studies suggesting that dialysis duration may reflect cumulative exposure to inflammation and dialysis-related complications rather than a direct factor associated with hypoalbuminemia [15].

4.6. Clinical Implications

Our results have important clinical and translational implications. First, they suggest the need to redefine the assessment of nutritional status in hemodialysis patients, considering that albumin should not be interpreted in isolation, but in the context of an underlying inflammatory state. Second, they highlight the importance of an integrated management approach, combining appropriate nutritional interventions, optimization of dialysis parameters, and consideration of the inflammatory process. Finally, these results underscore the need to improve dialysis practices, particularly through the use of more biocompatible membranes, strict control of dialysate water quality, and enhanced monitoring of chronic infections, in order to limit inflammation and improve patient outcomes [16].

4.7. Strengths and Limitations of the Study

This study presents several strengths, notably its pioneering nature as the first analysis conducted in this geographical context, the use of a robust multivariate model, and the production of clinically relevant data directly applicable to practice. However, some limitations should be considered, particularly the cross-sectional design, which does not allow causal inference, the relatively modest sample size, and the absence of complementary nutritional markers such as pre-albumin

or the MIS score. In this perspective, longitudinal studies incorporating more specific nutritional and inflammatory biomarkers would be necessary to better understand the dynamic evolution of the MIA syndrome and to optimize patient management in our context.

5. Conclusions

Hypoalbuminemia in chronic hemodialysis patients in Brazzaville is frequent and appears to be closely linked to persistent systemic inflammatory status. Inflammatory syndrome and diabetes mellitus constitute major factors associated with malnutrition, confirming the importance of the complex interaction between inflammation, metabolic disturbances, and impairment of nutritional status.

These results are fully consistent with the framework of the MIA syndrome (Malnutrition-Inflammation-Atherosclerosis), whose central role in the morbidity and mortality of hemodialysis patients is now well established. In our context, characterized by structural and socio-economic constraints, this interaction appears particularly pronounced, exposing patients to an increased risk of cardiovascular, infectious complications and mortality.

Beyond the simple optimization of dialysis parameters, our data highlight the need for a global and multidimensional approach to the management of hemodialysis patients.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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