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Relationship between Dietary Iron and Serum Hemoglobin Serum in People on Hemodialysis Treatment

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Abstract

Objective: To evaluate the relationship between dietary iron and serum hemoglobin in patients on hemodialysis. *Method*: Cross-sectional study involving 38 men receiving hemodialysis, aged between 31 and 51 years. Food consumption data were collected from the 24-hour recall and analyzed by software "Nutwin" version 1.5. Anthropometric measurements were taken using measuring tape and a digital scale Filizola® with a maximum capacity of 150 kg, where the nutritional status was determined according to the body mass index (BMI). Statistical analysis was conducted using the SPSS program v. 15.0 and Pearson's correlation to check the association between variables. *Results*: The mean iron intake was lower than the recommended levels, averaging 6.22 ± 7.41 mg / day. The average concentrations of biochemical parameters for hemoglobin, hematocrit and red blood cells were, respectively, 9.22 ± 1.48 g / dl, 28.79 ± 5.33, 3.15 ± 0.47, indicating the presence of anemia. There was no significant correlation between hemoglobin and iron in the diet (P <0.05). *Conclusion*: Considering the results, it can be assumed that anemia of patients on hemodialysis was not the result of low iron intake, but due to factors involved in the hemodialysis process.

Key words: Iron Deficiency. Anemia. Renal Insufficiency. Renal Dialysis.

Introduction

Kidneys are vital organs that help maintain human homeostasis, once the progressive reduction of the glomerular filtration rate (GFR) compromises the regulatory, excretory and endocrinal body functions. Chronic kidney insufficiency is characterized by being a progressive and debilitating disease, which causes disability and has a high mortality rate due to its high incidence and prevalence in the world.[1,2]

Patients suffering from chronic kidney disease (CKD) require hemodialysis, treatment that filters the blood and eliminates toxic wastes, which in excess can cause damages to the body. However, hemodialysis may have physiological, psychological and nutritional complications. [2,3]

Various nutrients are lost during hemodialysis, including trace elements or micro-minerals, among them iron, which, according to Silva et al.,[4] are necessary to maintain metabolic normality and adequate cells functioning. For this reason, supplementation of this mineral is advisable, once its increased excretion during the hemodialysis process may favor the development of anemia in these individuals. Furthermore, patients receiving hemodialysis have dietary restrictions that interfere with the insufficient supply of this mineral, and the use of phosphorous-chelating agents or calcium-based supplements may prevent the absorption of iron.[4-6]

Another aspect that should be mentioned is the production of erythropoietin by the kidneys, a protein responsible for the production of erythrocytes. In situations of kidney failure, there is a decrease of the erythropoietin synthesis by the renal parenchyma, which may also favor the development of anemia.[7,8]

Diet is vital in the treatment of chronic kidney disease because the amount of proteins, calories and other dietary nutrients must be adjusted to meet the new concentrations required to improve the clinical signs, succeed in the therapy and maintain or recover the patients' nutritional status.[9,10]

Considering the lack of data investigating the influence of hemodialysis on the nutritional status with respect to iron as well as the subject complexity, this study was of great importance, once it contributed to clarify the mechanisms involved in the development of hemodialysis-associated anemia.

Methodology

This is a cross-sectional study carried out with 38 men undergoing hemodialysis, aged between 31 and 51 years, selected by means of interviews. All participants were part of the spontaneous demand of the Center of Dialysis in Caxias, Maranhão, in the period of February to May 2014, and all of them signed the Free and Informed Consent Form. Not eligible to participate were smokers, alcoholics and/or those who presented liver diseases, used vitamin and mineral supplements and other drugs that could interfere with the diagnosis of anemia.

The body weight was determined using a Filizola® digital scale, with a maximum capacity of 150 kg, graduation of 100g; the participants were barefoot and wearing light clothes. Height was measured with a Seca® stadiometer, graduation in centimeters and with vertical, fixed wooden rod; participants were barefoot and wearing no accessories, feet together, in upright position, looking directly in front of them. Weight was measured in kilograms, height in centimeters, and the nutritional status of the participants was determined by the body mass index, according to the World Health Organization (WHO).[11] For collection of data on food intake we used the 24-hour recall, and the amount of energy, macronutrients and iron was calculated using the software *Nutwin*, version 1.5, of the Department of Health Information Technology at the Federal University of São Paulo.[12]

The foods not found in the software were included based on the Brazilian Table of Foods Composition.[13] The mean percentage of adequacy of minerals intake was calculated based on the Dietary Reference Intakes.

Anemia was determined by the concentration of hemoglobin obtained by the cyanmethemoglobin method using the *Labtest*® kit. The UV-visible spectrophotometer (FEMTO model 700S) was used for determination of hemoglobin, at a wavelength of 540nm. Data were organized in Excel® spreadsheets and exported to the software SPSS for Windows®, version 18.0 for statistical analysis of the results. The Kolmogorov-Smirnov tests were used to check for data normality, and Pearson's correlation to verify associations between the variables, using 95% confidence interval.

The project was referred to the Committee of the Higher Education Center of Caxias-UEMA and approved under number CAAE 26588914.5.0000.5554, as established by the Resolution no. 466/2012 of the National Health Council.

Results

The mean age of the patients was within the adult life cycle. Regarding the average BMI value, the patients were found to be at nutritional risk according to the new parameters adopted for this population, as shown in Table 1.

Table 1. Mean values and standard deviation of age and anthropometric parameters (weight, height and BMI) found in the profile of patients undergoing hemodialysis. Caxias-MA, 2014.

Parameters	Patients on hemodialysis Mean ± SD
Age (years)	41.73 ± 9.88
Weight (kg)	61.28 ± 10.43
Height (m)	1.64 ± 0.08
BMI (kg/ m^2)	22.62 ± 3.29*

BMI = Body Mass Index; BMI < 23 kg/m^2 indicates nutritional risk. *Cuppari[14]

The mean values for energy and macronutrients found in the diets consumed by the patients undergoing hemodialysis are described in Table 2. It can be seen that the intake of energy and lipids was low, adequate for carbohydrates and above the recommended level for proteins.

Table 2. Mean values and standard deviation of the intake of macronutrients by patients on hemodialysis. Caxias-MA, 2014.

Parameters	Mean ± SD	Recommended values
Energy (kcal)	1379.4 ± 389.65	-
Protein (g/kg/day)	1.32 ± 0.62	1.2*
Lipid (%)	23.8 ± 7.58	25 - 35#
Carbohydrate (%)	55.88 ± 10.56	50 – 60#

*Cuppari[15] Riella and Martins[16]

The results of the analysis of dietary fiber and iron intake by the patients on hemodialysis treatment revealed a low consumption of these nutrients (Table 3).

Table 3. Mean values and standard deviation of the intake of micronutrients, dietary fiber and iron by patients on hemodialysis. Caxias-MA, 2014.

Parameters	Mean ± SD	Recommended values
Dietary fiber (g)	7.89 ± 7.39	20 to 25
Iron (mg)	6.22 ± 7.41	10 to 18

Cuppari[15]

The mean values and standard deviation of the biochemical parameters for determination of anemia are available on Table 4. Hematocrit, red blood cells and hemoglobin were below the recommended levels.

Table 4. Mean values and standard deviation of the biochemical parameters for hematocrit, red blood cells (RBC) and hemoglobin in patients undergoing hemodialysis. Caxias-MA, 2014.

Parameters	Mean ± SD	Reference values
Hematocrit (%)	28.79 ± 5.33	38.0 – 50.0
RBC (million/mm^3)	3.15 ± 0.47	4.3 – 5.7
Hemoglobin (g/dL)	9.22 ± 1.48	13.0 – 17.5

The results of the correlation analysis between the parameters are described on Table 5. The present study did not find a significant correlation between hemoglobin and dietary iron concentrations.

Table 5. Simple linear correlation between hemoglobin and dietary iron. Caxias-MA, 2014.

Parameters	Linear correlation	
	r	p
Hemoglobin (g/dL) x Dietary Iron (mg)	0.077	0.640*

*Pearson´s linear correlation ($p<0.05$).

Discussion

This study evaluated the dietary iron intake and the levels of hematocrit, red blood cells (RBC) and hemoglobin in patients undergoing hemodialysis and investigated the correlation between the biochemical parameters and dietary iron. It was found that the mean age of the patients characterizes the study population as adults. According to studies conducted by Godinho et al.,[17] the age of most of the patients on hemodialysis in Brazil was between 40 and 50 years.

Despite the debilitating condition associated with the pathology, the participants had normal weight according to the WHO classification for BMI. Similar results were found by Pinto et al.[18] and Oliveira et al.,[19] who also identified normal weight in patients with chronic renal insufficiency receiving hemodialysis.

However, new studies have described that the classification of nutritional status based on the BMI of patients with chronic renal insufficiency and undergoing hemodialysis treatment presents some differences in relation to the cutoff indicated by WHO.[11] According to Cuppari,[14] BMI values below 23 kg/m² have been an indicator of nutritional risk for these patients, for its association with morbidity and mortality.

Furthermore, BMI is not sensitive to determine protein depletion as well as visceral fat increase, reinforcing the idea that individuals with normal BMI levels may be at risk in a different way. Based on this new classification, most of the patients of the present study are at nutritional risk. Regarding the patients' dietary intake, it was observed heterogeneity on the consumption of macronutrients, because the levels of calorie and lipids were low and proteins were above the recommended levels. This corroborates the BMI findings below the acceptable levels for these individuals.

On the other hand, Peters et al.[20] and Valenzuela et al.[21] found deficient protein intake by patients on hemodialysis, associating it to protein-energy malnutrition resulting from this condition. However, the carbohydrate intake in both studies was above the recommended values found in the literature. According to Riella and Martins,[22] carbohydrates should supply about 35% of the total calories estimated for the day because of the constant absorption of glucose in patients on hemodialysis.

It is important to mention that protein intake above the recommended values also maintain a positive nitrogen balance. According to Cabral et al.,[23] patients receiving hemodialysis need high protein intake due to the great loss of this nutrient in the dialysis process, which does not occur with fats, which must be balanced in the diet because of overweight incidence. With regard to the low calorie values found, they might have been influenced by the study method chosen, once the 24-hour recall may underestimate the amount of energy because it depends on the patient's memory and may be influenced by the researcher during data collection. According to Dodd,[24] the method does not represent effectively the regular food intake because it restricts the variability of nutrient intake in different days. However, despite the limitations, this method has the characteristic of being quick, practical and cost effective.

Regarding dietary iron, it was found a deficient intake of this nutrient, which might have been influenced by the patients' low-calorie diet, once low energy consumption reduces the availability of food source of iron. According to Cuppari,[14] the recommended dietary iron intake by patients on hemodialysis are similar to that of healthy individuals, between 10-18 mg/day.

The literature states that the lack of iron leads to the development of anemia. This, in turn, results in increased morbidity and mortality of patients on hemodialysis, reducing the quality of life of these individuals. Rossert[25] states that anemia resulting from the decreased number of nephrons contributes to worsening the tubulointerstitial fibrosis process of chronic nephropathies through hypoxia and oxidative stress.

In addition, anemia affects negatively numerous organic functions, such as the oxygen transport to the tissues, oxidation and reduction reactions, humoral and cellular immunity, and synthesis of deoxyribononucleic acid (DNA) and neurotransmitters.[26-28]

The average intake of dietary fibers was also below the recommended levels, corroborating the results reported by Chaves et al.,[29] who found that individuals undergoing hemodialysis had inadequate intake of dietary fibers and iron. In this regard, patients suffering from chronic renal failure often have constipation, which results from physical inactivity, use of phosphorous-chelating agents, iron supplements, restriction of foods rich in potassium and phosphorous, which are also fiber sources. Therefore, these patients require food re-education.

Serum concentrations of hematocrit, red blood cells and hemoglobin were below the reference values, indicating that the patients on hemodialysis had anemia. Similar results were found by Draczevski & Teixeira,[30] who also revealed anemia in individuals undergoing this treatment. According to Paiva et al.,[31] hemoglobin is the parameter universally used to diagnose anemia, once it is has a significant amount of iron.

A major aspect to be considered is related to the results of the test performed to investigate the relationship between dietary iron and hemoglobin concentrations. In this regard, deficient iron intake seems not to have influenced the patients' anemia, once there were no correlations between the above-cited parameters.

About this result, it should be noted that the diagnosis of anemia in patients might be based on other factors that are inherent to renal insufficiency, such as deficiency of erythropoietin protein, which production is impaired in individuals with kidney failure. According to Abensur,[32] erythropoietin is produced by the kidneys, being the main factor related to alterations in erythropoiesis (synthesis of red blood cells). Its reduction prevents the release of iron from macrophages, which leads to a decline of the mineral available for the synthesis of hemoglobin.

In addition, the hemodialysis process leads to micronutrients spoliation, among them iron, a mineral that contributes to the production of erythropoietin.[33] Thus, the anemia diagnosed in the participants of this study may also have been caused by excessive elimination of iron during the hemodialysis process.

As indicated by the studies by Martins et al.[34], the major nutritional problems in these individuals are related to the accumulation of metabolites between the dialysis sessions and the loss of nutrients during the procedure. According to Canzianni et al.,[27] anemia appears in the stages prior to dialysis treatment, so the diagnosis of this pathology is crucial in order to reduce complications. Therefore, hemoglobin should be measured in all CKD patients, and for this reason it is advisable to assess it at least once a year.[35]

Thus, we can assume that the iron-deficient anemia in the participants of the study seems to be due to renal insufficiency and the hemodialysis treatment, and not to a low dietary intake of this micronutrient. However, the limitations of this study do not allow for a conclusive result, once the concentrations of serum iron, ferritin and the total iron-binding capacity were not assessed.

Taking into account the importance of these analyses for more conclusive results, Paiva[36] says that ferritin is an effective measure because it uses peripheral blood and determines strong correlation with iron deposits in the tissues. Serum iron is a parameter widely used, indicating alterations in the presence of infectious processes and showing its decreased concentration during an infection. The total iron-binding capacity used to investigate current iron increases when this mineral is deficient, but decreases during inflammation processes.

Conclusion

Based on the results of this study, it can be seen that the patients undergoing hemodialysis treatment have deficient iron intake, and this, in turn, does not seem to influence the low concentrations of the biochemical parameters for hemoglobin, hematocrit and RBC. In this regard, the participants' anemia seems to result from multiple factors, some of them associated with renal insufficiency, with reduced production of RBC or spoliation of minerals during the hemodialysis process.

Given the above, further studies are suggested in order to clarify the relationship between anemia and hemodialysis and to help in the development of strategies for interventions either in the prevention or treatment of complications associated with CKD.

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