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Clinical and Biological Profile and Factors Associated with High Blood Lead Levels in Chronic Hemodialysis Patients in a Western French Guiana Hospital Center

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Abstract

Background: Lead is toxic to the body. Its chronic intoxication combines various clinical and biological disorders that can be life-threatening. In French Guiana, lead poisoning is particularly worrying, as the incidence rate is nearly sixty times higher than in metropolitan France. In chronic hemodialysis patients, lead levels are often higher and can lead to several adverse consequences. Hence, the interest of this study, which is to describe the clinical and biological characteristics of chronic hemodialysis patients with high blood lead levels and to identify the associated factors to draw attention to its screening and the prevention of its complications.

Methods: Descriptive and analytical cross-sectional study that included 65 patients on chronic conventional hemodialysis: With an annual biological assessment in December 2022, including a serum lead assay. The outcome was the notion of hyper lead level, defined by a lead level >85 µg/l. We described the clinical, biological, and dialytic parameters of patients with hyper lead levels and in logistic regression, we identified the factors that are correlated according to a significance threshold P<0.05.

Results: In all, 54% of patients had hyperplumbemia, 2/3 of them women. They were older with an average age of 62. None of the patients had been occupationally exposed to lead. 94% were hypertensive and half were diabetic. 26% had anemia, and half had erythropoietin resistance. Their ferritin levels were slightly lower, with a mean of 721 µg/l. Mean albumin was 30 g/l, prealbumin 28 g/l, mean parathyroid hormone 1355 ng/ml, NT-pro BNP 9144 ng/ml. Mean CRP was 10.8 mg/l. They had collapsed residual diuresis and natriuresis with averages of 141 ml and 12 mmol/24 hours, respectively. There was a significant positive correlation between high Blood Lead Level (BLL) levels and young age, and a negative correlation with female gender, low serum albumin, prealbumin, protein and ferritin levels, as well as collapsed residual diuresis.

Conclusion: High blood lead levels are common in the Guyanese chronic hemodialysis population in which it is correlated with female sex, malnutrition, iron deficiency and residual poor renal function and probably with resistance to erythropoietin treatment. It is necessary to screen in at-risk populations to prevent complications associated with it.

Keywords: Chronic intoxication • Hemodialysis • Lead • Dialysis parameters • Diabetic • Anemia

Introduction

Lead (Pb) is one of the most toxic heavy metals [1]. Chronic intoxication is associated with a range of clinical and biological disorders that can be life-threatening. The WHO estimates that nearly one million lives will be lost due to exposure to chemicals in 2019. Lead exposure is estimated to account for 21.7 million years of disability and death due to long-term health effects and is responsible for 30% of the global burden of idiopathic intellectual disability, 4.6% of the global burden of cardiovascular disease and 3% of the global burden of chronic kidney disease [2]. According to a study by the Institut de Veille Sanitaire (InVS), the prevalence of lead poisoning in adults in mainland France is 1.7% [3]. In French Guyana, lead poisoning is a cause for concern, as its incidence [illegible] is almost [illegible] times greater than that in mainland France. Between 2015 and [illegible], 18,285 primary lead screening tests were carried out in France, including French Overseas Departments and Regions (DROM). Over the same period, 2,[illegible] lead tests were carried out in French Guiana, representing 12% of the total, even though the population of French Guiana represented only 0.42% of the French population (including the DROM population) in 2019. Unlike the etiological factors encountered in mainland France, French Guiana is unusual in that the etiological origin of lead poisoning is mainly local dietary [4], making preventive measures more complex in territories where most of the population is of ancestral cosmopolitan origin and where almost half of the population lives below the poverty line [5]. In chronic hemodialysis patients, blood lead levels are often greater than those in the general population and can have several adverse consequences in terms of morbidity, mortality, and cardiovascular risk. Hence, the purpose of this study was to describe the clinical and biological characteristics of chronic hemodialysis patients with elevated blood lead levels and identify the associated factors to determine the need for screening and prevention of complications.

Materials and Methods

We conducted a descriptive and analytical cross-sectional study at the hemodialysis center of the Centre Hospitalier de l'Ouest Guyanais in December 2022. All chronic hemodialysis patients who had undergone their annual biological check-up, including blood lead levels, in December 2022 and who freely consented to the study were included. The exclusion criterion was the anamnestic notion of occupational exposure to lead. Therefore, no patient

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was excluded from the study because there was no anamnestic evidence of occupational exposure to lead. Blood lead levels were determined using the inductively coupled plasma mass spectrometry technique. The primary endpoint was hyperplumbemia, defined as a blood lead concentration >85 µg/l. The data were transferred to Excel 2010, and the statistical analysis was performed using STATA 16.0. We described the clinical, biological, and dialytic parameters of patients with hyperleadaemia compared with patients with blood lead levels ≤ 85 µg/l, and a logistic regression model was constructed to identify factors correlated with hyperleadaemia at a significance level of P<0.05.

Results and Discussion

Table 1 shows that 35 patients had elevated lead levels, with an average blood lead level of 120 µg/l. Sixty-six percent of the participants were female. The participants were older, with an average age of 62 years. A total of 94% were hypertensive, and 67% were diabetic. Twenty-six percent had anemia. Ferritin levels were slightly lower, with a mean of 721 µg/l. The mean serum ALB concentration was 30 g/l, the mean prealbumin concentration was 28 g/l, the mean parathyroid hormone concentration was 1355 ng/ml, and the mean NT-pro BNP concentration was 9144 ng/ml. The mean CRP concentration was 10.8 mg/l. Vitamin C levels were lower, with an average of 3.66 mg/l. The patients had collapsed residual diuresis, natriuresis, [illegible]sis and chloriuresis, with mean values of 150 ml, 11.5 mmol, 3.[illegible]6 and 8.64 [illegible]/ 24 hrs, respectively (Table 1).

Following the statistical analysis, the following results were obtained: 5[illegible]% of the patients had hyperleadaemia (Figure 1), with an average of 120 µg/l, 2/3 of whom were women. The participants were older, with an average age of 62 years. None of the patients had been occupationally exposed to lead (Figure 1).

Ninety-four percent were hypertensive, and half were diabetic. One-fourth of the patients were anemic, and all had erythropoietin resistance. Her ferritin levels were slightly lower, with a mean of 721 µg/l. The mean serum ALB concentration was 30 [illegible] the prealbumin concentration was 28 g/l, and the mean parathyroid hormone concentration was elevated to 1355 ng/ml. The mean CRP concentration was [illegible]0.8 mg/l. The vitamin C levels were significantly lower. The patients had collapsed residual diuresis, natriuresis, chloriuresis and kaluresis. There were significant positive correlations between high lead levels and young age; negative correlations with female sex; low serum ALB, prealbumin, protein and ferritin levels; and collapsed residual diuresis (Figure 2).

Table 1. Breakdown of clinical and biological parameters by blood lead level.

	Pb 0 (n = 30)	**Pb 1 (n = 35)**	**n**	**P**
Lead (µg/l), median [Q25-75]	59.8 [49.1; 75.2]	120 [1[illegible]	65	<0.001
Uric acid (mmol/l), mean (SD)	404 (88.0)	352 (67.[illegible])	65	<0.01
Albumin (g/l), mean (SD)	28.0 (3.98)	30.2 (3.93)	65	0.012
Aluminum (µg/l), mean (SD)	2.91 (0.620)	2.94 (0.705)	65	0.66
2-Beta microglobin (mg/l), mean (SD)	30.6 (10.8)	31.6 (8.84)	65	0.5
BMI (kg/m²), mean (SD)	24.9 ([illegible].82)	26.3 (6.67)	65	0.38
Plasma calcium (mmol/l), mean (SD)	[illegible].23 ([illegible]1)	[illegible].30 (0.184)	65	0.2
Urinary chloride (mmol/l), mean (SD)	19.2 (27.6)	8.64 (16.7)	65	0.029
Urinary creatinine (mmol/l), mean (SD)	3.49 (4.90)	0.926 (1.99)	65	<0.01
CRP (mg/l), mean (SD)	18.0 (1[illegible].7)	10.8 (22.1)	65	<0.01
Ferritin (ng/[illegible]), mean (SD)	7[illegible] (450)	722 (490)	65	0.68
[illegible]S (%), mean (standard deviation)	31.1 (14.1)	29.4 (12.6)	65	0.64
Residual urine output (ml/24 h), mean (SD)	398 (439)	141 (279)	65	<0.01
Erythropetin µg/kg/s, mean (SD)	1.11 (0.996)	1.13 (1.64)	65	0.24
Blood glucose (mmol/l), mean (SD)	5.20 (2.22)	6.28 (4.45)	65	0.91
Hemoglobin (g/l), mean (SD)	10.1 (1.74)	11.1 (1.95)	65	0.038
Plasma HCO3 (mmol/l), mean (SD)	21.1 (2.84)	22.0 (2.22)	65	0.17
Plasma potassium (mmol/l), mean (SD)	4.41 (0.888)	4.44 (0.598)	65	0.98
Urinary potassium (mmol/l), mean (SD)	8.38 (10.0)	3.73 (7.28)	65	0.014

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Plasma magnesium (mmol/l), mean (SD)	0.777 (0.111)	2.32 (8.99)	65	0.42
Plasma sodium (mmol/l), mean (SD)	137 (3.71)	137 (3.25)	65	0.86
Urinary sodium (mmol/l), mean (SD)	29.0 (38.8)	11.5 (22.1)	65	0.0[illegible]
NT-proNP (ng/ml), mean (SD)	12813 (28657)	9144 (16048)	65	[illegible]68
Phosphorus (mmol/l), mean (SD)	4.41 (16.7)	1.14 (0.383)	65	0.0[illegible]
Dry weight (kg), mean (SD)	67.4 (20.7)	69.3 (17.4)	65	0.7
Prealbumin (g/l), mean (SD)	30.1 (8.74)	28.1 (10.6)	65	0.4
Total protein (g/l), mean (SD)	68.4 (7.51)	67.6 (9.30)	65	0.97
PTH (ng/ml), mean (SD)	985 (815)	1355 (1062)	65	0.21
TSH (mIU/l), mean (SD)	1.40 (1.27)	1.21 (0.748)	65	0.67
Vit B12 (ng/l), mean (SD)	469 (497)	487 (3[illegible]6)	65	0.48
Vit B9 (µg/l), mean (SD)	917 (637)	777 (641)	65	0.2
Vit C (mg/l), mean (SD)	11.4 (14.0)	3.66 (3.55)	65	<0.01
VIT D (ng/ml), mean (SD)	33.5 (14.6)	38.1 (13.0)	65	0.19
KT/V Average, mean (SD)	1.13 (0.226)	1.20 (0.197)	65	0.23
AGE (years), mean (SD)	50.2 (1[illegible].6)	61.6 (14.2)	65	<0.01
Diabetes, n	21 ([illegible]%)	22 (63%)	43	0.54
Hypertension, n	9 (30%)	13 (37%)	22	-
	28 (93%)	33 (94%)	61	1
Sex, n	2 (6.7%)	2 (5.7%)	4	-
	13 (43%)	23 (66%)	36	0.07
	17 (57%)	12 (34%)	29	-
LVEF (%), mean (SD)	6[illegible].6 (6.80)	65.3 (5.97)	65	0.64

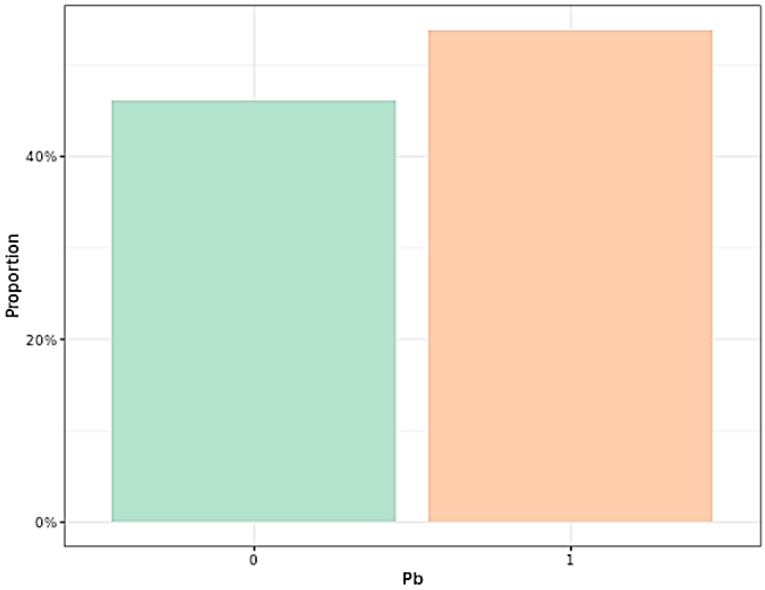

Figure 1. Distribution of high blood lead levels. 1= High blood lead level (≥ 85 µg/l), representing approximately 53.85% of the total. 2= Normal blood lead concentration (< 85 µg/l).

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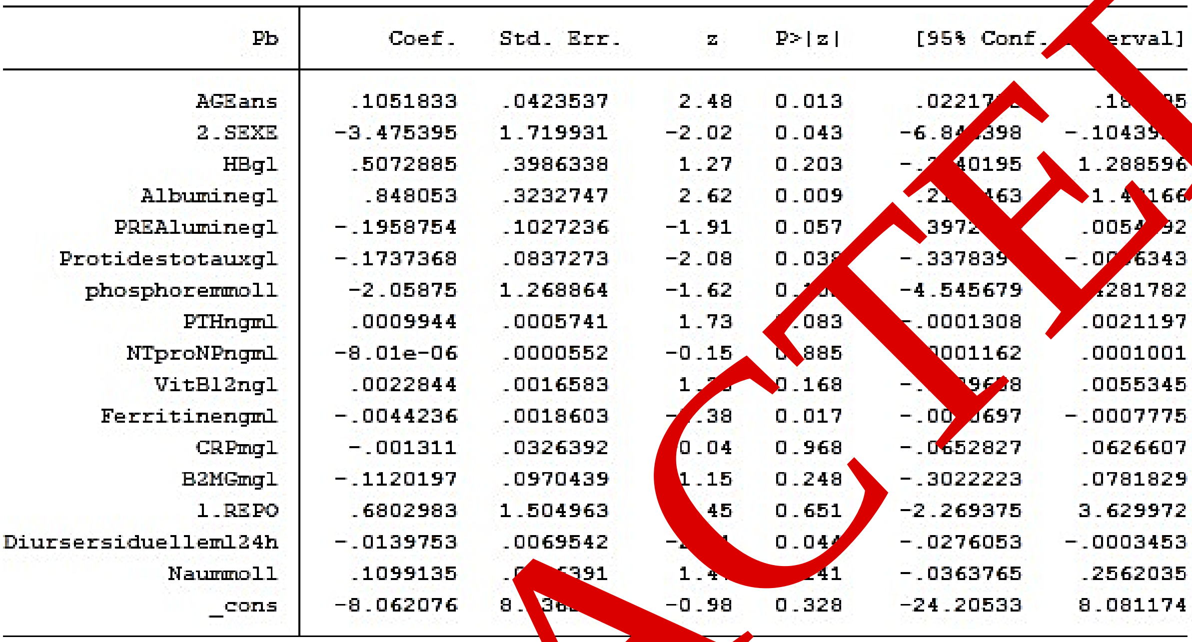

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                   Pb |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
----------------------+----------------------------------------------------------------
               AGEans |   .1051833   .0423537     2.48   0.013     [illegible]  [illegible]
               2.SEXE |  -3.475395   1.719931    -2.02   0.043     [illegible]  [illegible]
                 HBgl |   .5072885   .3986338     1.27   0.203     [illegible]    1.288596
           Albuminegl |    .848053   .3232747     2.62   0.009     [illegible]  [illegible]
         PREAluminegl |  -.1958754   .1027236    -1.91   0.057     [illegible]  [illegible]
     Protidestotauxgl |  -.1737368   .0837273    -2.08   [illegible]  -.337839   [illegible]
       phosphoremmoll |   -2.05875   1.268864    -1.62   [illegible] -4.545679   [illegible]
             PTHngml |   .0009944   .0005741     1.73   [illegible] -.0001308    .0021197
          NTproNPngml |  -8.01e-06   .0000552    -0.15   [illegible] [illegible]    .0001001
            VitB12ngl |   .0022844   .0016583   [illegible] 0.168   [illegible]    .0055345
          Ferritinengml |  -.0044236   .0018603   [illegible] 0.017   [illegible]  -.0007775
               CRPmgl |   -.001311   .0326392   [illegible] 0.968   [illegible]    .0626607
              B2MGmgl |  -.1120197   .0970439   [illegible] 0.248    -.3022223    .0781829
               1.REPO |   .6802983   1.504963   [illegible] 0.651    -2.269375    3.629972
   Diursersiduelleml24h |  -.0139753   .0069542   [illegible] [illegible] -.0276053  -.0003453
             Naummoll |   .1099135   [illegible] [illegible] [illegible] -.0363765  .2562035
                _cons |  -8.062076   [illegible]  -0.98   0.328    -24.20533    8.081174
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Figure 2. Multivariate analysis: Factors associated with high lead levels. Multivariate analysis revealed that at the 5% threshold, the factors significantly associated with high lead levels were age, sex, albumin concentration, protidemia, ferritin level and residual diuresis.

These results corroborate other findings in the literature. Natale Calleon et al. reported that chronic Hemodialysis (HD) patients had significantly greater mean blood lead levels than healthy individuals [illegible] (p<0.0[illegible]) [illegible] significant percentage of the HD population (13%) had values above 30 µg/dl, the risk threshold for occupational exposure, and 4% had values above 40 µg/dl. High diastolic blood pressure was associated with blood lead levels above 30 µg/dl (p < 0.01), and a correlation was found between blood lead and parathyroid hormone levels [6]. In contrast, our study revealed no associations between sex or age and the duration of dialysis. This difference can be explained by the fact that our dialysis population is predominantly composed of elderly patients, with a predominance of women. Huang et al., on the other hand, reported a negative correlation between elevated lead levels and the dose of recombinant Erythropoietin (EPO). This finding is in line with our results since, although not significantly, the weekly erythropoietin level was slightly greater in patients with hyperleadaemia. This could be explained by the fact that lead intoxication is responsible for inflammation and oxidative stress [7], both of which are involved in resistance to EPO, as well as the association that hyperleadaemia [illegible] have with other EPO resistance factors, such as hyperparathyroidism, undernutrition and hypovitaminosis C; in this case, these conditions were significantly associated with hyperleadaemia in the present study, which could be explained, among other things, by its excessive consumption due to the oxidative stress generated by lead intoxication. In their study, Rahmat Pouresmaeil et al. concluded that hyperleadaemia was associated with inflammation (CRP>3 mg/l), malnutrition, iron deficiency and elevated parathyroid hormone levels in chronic hemodialysis patients [8]. In our study, this could translate to a biological inflammatory syndrome with a mean CRP of 10.8 mg/l, undernutrition (low albumin and prealbumin levels), and iron deficiency (lower mean ferritin). Similarly, other authors have investigated the correlation between blood lead levels and inflammation and malnutrition in diabetic chronic hemodialysis patients and found that hyperleadaemia could contribute to inflammation and nutritional status in diabetic chronic hemodialysis patients [9]. In the same study, hyperleadaemia was also shown to be linked to mortality at one year in chronic diabetic hemodialysis patients and, in another similar study, to all-cause mortality at 18 months in peritoneal dialysis patients [10]. This situation could be explained in part by the increased cardiovascular risk, for which hyperleadaemia is thought to be responsible for inflammation, chronic malnutrition, and atherosclerosis [11]. The present study revealed a negative correlation between hyperleadaemia and residual diuresis, with hyperleadaemia associated with a collapse in residual diuresis, natriuresis, kaliuresis and chloriuresis; Dialysis is an important factor associated with survival and quality of life [12]. Other associations have been found by other authors but were not investigated in this study, notably, that of hyperleadaemia with carpal tunnel syndrome in chronic hemodialysis patients [13,14] or with uremic pruritus; However, these associations may be verified indirectly through the mechanisms described above, including chronic inflammation.

Conclusion

High blood lead levels are common in the Guyanese chronic hemodialysis population and are correlated with female sex, malnutrition, iron deficiency, poor residual renal function and likely resistance to erythropoietin treatment. It is necessary to screen at-risk populations to prevent complications associated with this procedure.

Acknowledgments

Not applicable.

Declarations

Author (s) declares that there are no source of funding and no conflicts of interest in this work

Ethics approval and consent to participate

This study was approved by the ethical and scientific committee of the Centre Hospitalier de l'Ouest Guyanais, and informed consent was obtained from all the participants.

Consent for publication

Not applicable.

Availability of data and materials

Available as a supplement to the present manuscript.

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Competing interests

The authors declare that they have no competing interests.

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