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Blood Ionogram Profile in Patients with Renal Insufficiency in Lubumbashi, Democratic Republic of the Congo

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Abstract

The kidneys play a vital role, particularly in filtering the blood, which results in urine production. This study aimed to evaluate the variation of different blood ions, including sodium, potassium, chloride, magnesium, calcium, and phosphate, in patients with kidney failure in Lubumbashi, and to investigate the statistical associations between these ions and sex, age, and serum creatinine levels. This was a descriptive cross-sectional study conducted from March 2nd to June 30th, 2025. Convenience sampling was used, with 180 patients with acute and chronic kidney disease admitted and followed up at two medical facilities: the Downtown Medical Center and the Lubumbashi Community Medical Center. Biomedical analyses were performed at the Lubumbashi Community Medical Center laboratory using a Selectra Pro S clinical biochemistry analyzer. Data were entered into Excel 2016 and processed using SPSS version 23. Males were more numerous (68.33%), with a male-to-female ratio of 2.16. Binary logistic regression showed no statistically significant association between the sex of the respondents and the measured ion levels ($p > 0.05$). The mean age was 45 ± 18 years, with a large proportion (41.11%) over 50 years of age. Pearson's correlation between age and measured ion levels also showed no statistically significant association ($p > 0.05$). 97.22% of respondents had hyperuricemia, and all had hypercreatininemia (100%). The single-sample t-test for uric acid and creatinine levels was statistically significant ($p = 0.000$). Pearson correlation between serum creatinine and the analyzed ions revealed statistically significant associations for serum calcium, potassium, magnesium, and phosphorus ($p < 0.05$). However, no statistically significant associations were

found for serum sodium and chloride ($p > 0.05$). The measured ions revealed 50% hyponatremia and 5.56% hypernatremia. The single-sample t-test was not statistically significant ($p = 0.052$). The following ion levels were also observed: 12.78% hypokalemia and 30% hyperkalemia; 37.78% hypochloremia and 7.22% hyperchloremia; 21.67% hypocalcemia and 10.56% hypercalcemia; 5.56% hypomagnesemia and 30.56% hypermagnesemia. 2.22% hypophosphatemia and 32.78% hyperphosphatemia. The single-sample T-test was statistically significant ($p < 0.05$) for the other ions. Therefore, we recommend that clinicians take this into account when requesting biomedical analyses for this category of patients.

Subject Areas

Biochemistry

Keywords

Blood Ionogram, Profile, Patients, Renal Insufficiency, Lubumbasshi

1. Introduction

Physiologically, the kidneys play an essential role, particularly in filtering the blood, which results in urine production. Toxic organic waste products are eliminated via urine; otherwise, they can cause various kidney diseases, including renal failure [1]. From a biological perspective, the medical management of patients with renal failure involves correcting the associated biological abnormalities, which increase with the progression of the disease. The multiple changes in biological parameters are factors linked to this condition, and correcting them improves the chances of successful treatment and, above all, the monitoring of renal failure [2].

The World Health Organization (WHO) adopted a resolution in 2025 aimed at promoting kidney health and strengthening the prevention and control of chronic kidney disease to reduce the burden of noncommunicable diseases worldwide [3]. Kidney diseases, including acute kidney injury, chronic kidney disease, and acute kidney injury, constitute a group of conditions that impair kidney function over varying time scales and with varying degrees of complexity [4]. Kidney failure is a disease of concern in both developed and developing countries. Many people are affected each year, and their number is increasing at a rate of 6% to 8% globally. One in ten adults suffers from kidney disease, representing nearly 600 million people worldwide. The WHO projects a 17% increase in the next ten years [2].

Electrolytes play a vital role in the body for maintaining life, specifically by maintaining cellular electrical neutrality and by generating and conducting action potentials in nerves and muscles. Important electrolytes include sodium, potassium, chloride, magnesium, calcium, phosphate, and bicarbonates. Electrolytes are obtained from our diet and hydration. Electrolyte imbalances can lead to hy-

per- and hypo-concentrations, which can be fatal due to disruption of normal bodily functions [5]. The measured ions explore three key areas in the body: fluid balance and blood pressure (sodium and chloride ions); neuromuscular and cardiac excitability (potassium, magnesium, and calcium ions); and bone structure and energy metabolism (calcium and phosphorus ions) [5] [6].

In the Democratic Republic of the Congo, several studies have addressed kidney diseases. In particular, studies conducted on the prevalence of kidney disease in the city-province of Kinshasa estimated it to be between 12.4% and 19.8%. Studies conducted in Lubumbashi assessed the financial accessibility of hemodialysis for kidney failure patients and their mortality risk factors; they also examined chronic kidney disease, addressing associated factors, etiology, and clinical and biological characteristics [7]; and they analyzed the epidemiological and nutritional profile of kidney failure patients at the University Clinics of Lubumbashi in the Democratic Republic of the Congo [8]. The aim of this study was to evaluate the variation of different blood ions, including sodium, potassium, chloride, magnesium, calcium and phosphate in renal failure patients in Lubumbashi and to study the statistical associations between these ions and sex, age and creatinine levels.

2. Materials and Methods

This is a descriptive cross-sectional study conducted from March 2 to June 30, 2025. Fasting blood samples and anthropometric data were collected on a convenience basis from 180 acute and chronic renal failure patients received and followed up in two medical facilities, including the Downtown Medical Center (CMDC) and the Lubumbashi Community Medical Center (CMC), after obtaining verbal consent from the heads of these hospital facilities, the adult patients, and the heads of the minor patients.

However, biomedical analyses were performed at the Lubumbashi Community Medical Center (CMC) laboratory using a Selectra Pro S clinical biochemistry analyzer. This analyzer is the most compact biochemistry analyzer available, offering enhanced performance for biochemistry analyses as well as a state-of-the-art user interface. With a throughput of 140 tests per hour (266 tests per hour with the ISE "Ion-Selective Electrode" module), it offers a full range of dedicated, ready-to-use reagents for an integrated biochemistry service. The reference values of the biochemical parameters analyzed are as follows: Uremia (15 - 45 mg/dL), creatininaemia (0.60 - 1.36 mg/dL), natremia (135 - 145 mmol/L), kalemia (3.5 - 5 mmol/L), calcemia (8.10 - 10.40 mg/dL), magnesemia (1.60 - 2.55 mg/dL), phosphoremia (3 - 5 mg/dL), chloremia (99 - 110 mg/dL) [9].

The data were entered in Excel 2016 and processed using SPSS 23 software (Statistical Package for social Science version 23).

3. Results

Figure 1 reveals that the male sex (68.33%) was superior to the female sex

(31.67%). The sex ratio was 2.16 in favor of males.

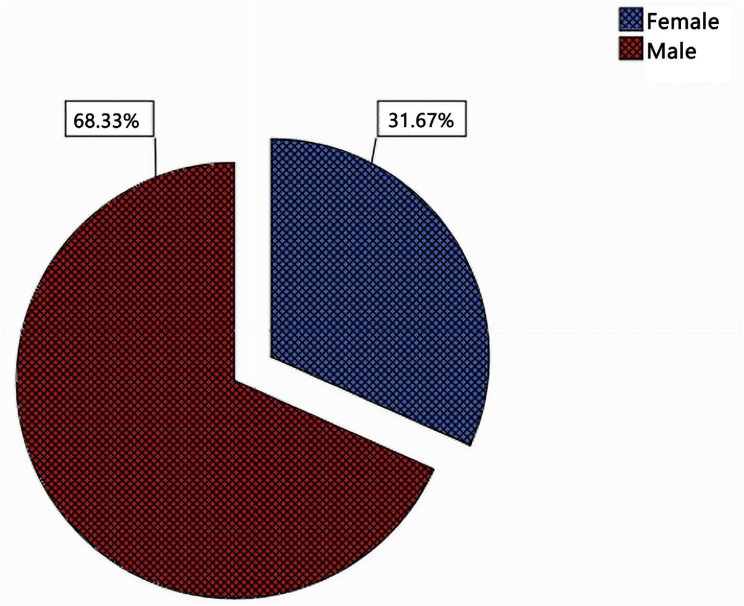

Figure 1. Distribution of cases by sex.

Figure 2 shows that, the majority of patients with kidney failure were over 50 years of age (41.11%), followed by those aged between 41 and 50 (21.11%), and then the others. The mean age was 45 ± 18 years, with an age range of 6 to 89 years.

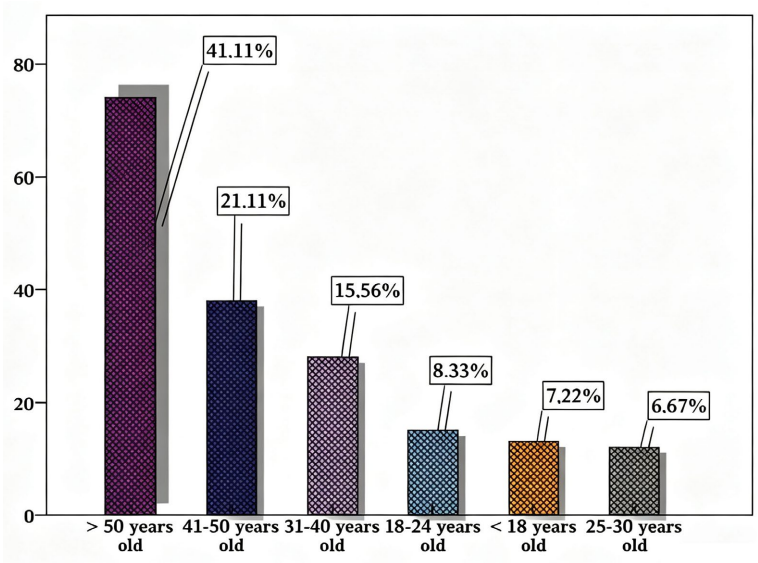

Figure 2. Distribution of cases by age group.

Figure 3 shows that 80.56% of kidney failure patients were from Lubumbashi; 8.89% came from Kolwezi; 2.78% from Likasi and the other proportions covered the other districts.

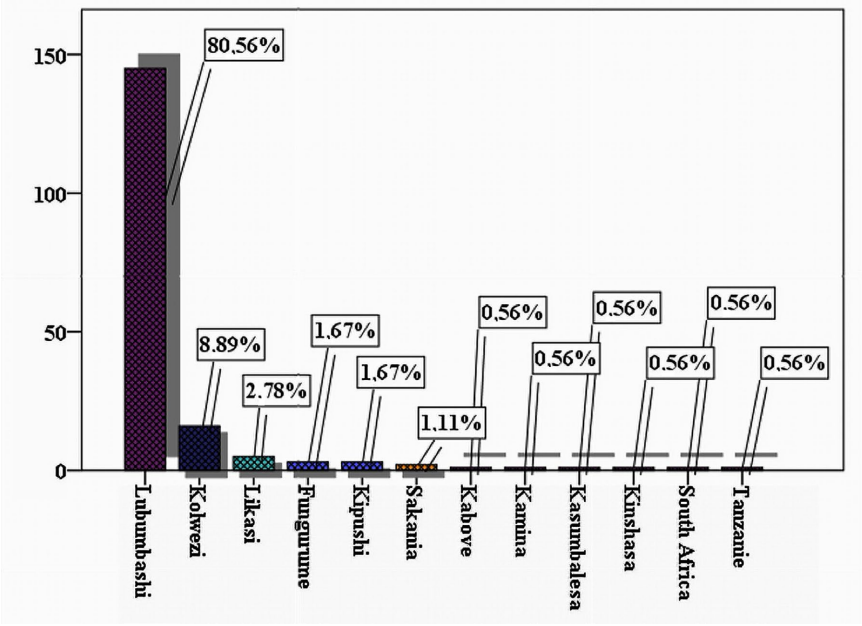

Figure 3. Distribution of cases according to the patients' origin.

Figure 4 shows that 97.22% of respondents had hyperuremia. The mean uremia level was 162 ± 91 mg/dL, with extreme values ranging from 36.41 to 49.4 mg/dL. The single-sample t-test was statistically significant (p = 0.000).

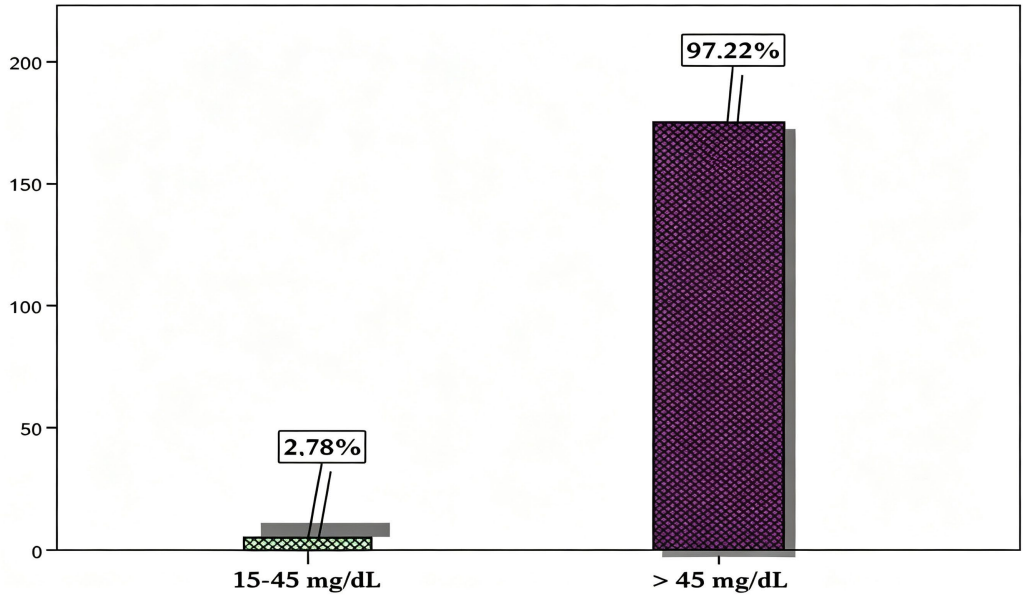

Figure 4. Distribution of cases according to uremia levels.

Figure 5 reveals that all respondents had hypercreatininemia (100%). The mean creatininemia level was 7 ± 4 mg/dL, with extreme values ranging from 1.40 to 25.80 mg/dL. The single-sample t-test was statistically significant (p = 0.000).

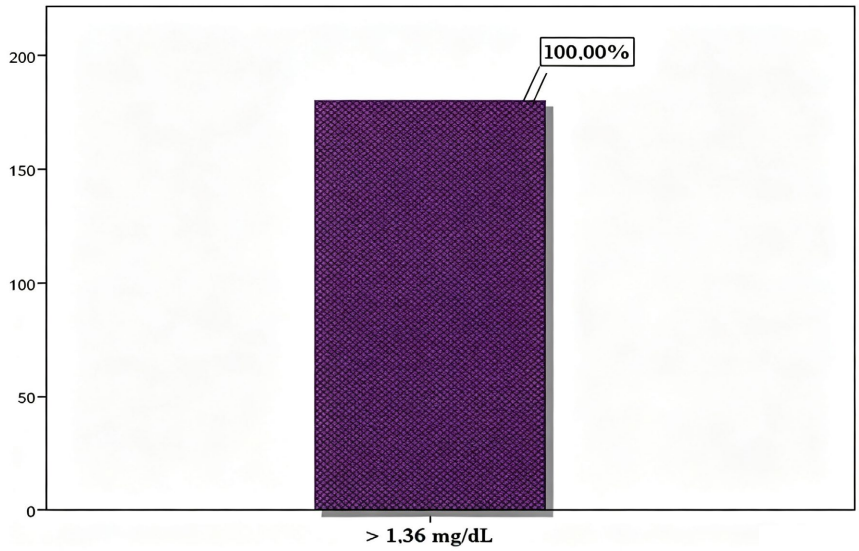

Figure 5. Distribution of cases according to the rates of creatininemia.

Figure 6 reveals that 50% of respondents had hyponatremia and 5.56% had hypernatremia. The mean natremia level was 135 ± 6 mmol/L, with a range of 116.0 - 157.8 mmol/L. The single-sample t-test was not statistically significant (p = 0.052).

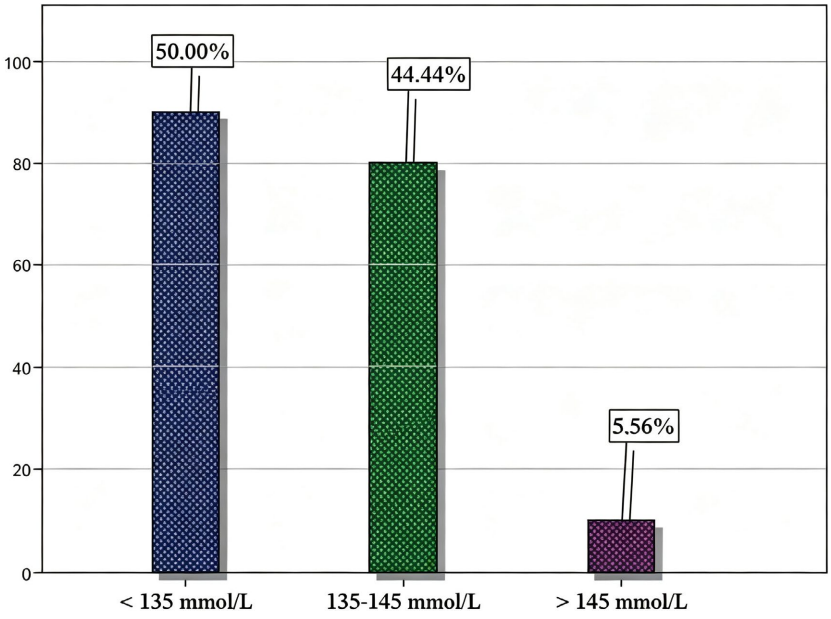

Figure 6. Distribution of cases according to rates of natremia.

Figure 7 shows that 12.78% of respondents had hypokalemia, while 30% had hyperkalemia. The mean kalemia level was 4 ± 9 mmol/L, with extreme values ranging from 2 to 7.6 mmol/L. The single-sample t-test was statistically significant (p = 0.000).

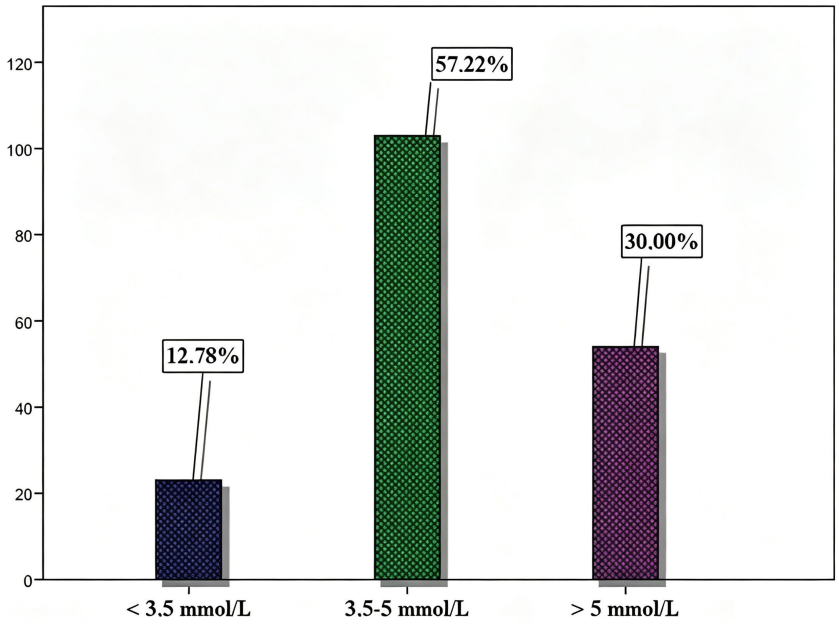

Figure 7. Distribution of cases according to kalemia levels.

Figure 8 shows that 37.78% of respondents had hypochloremia and 7.22% had hyperchloremia. The mean chloremia level was 100.7 ± 5 mg/dL, with extreme values ranging from 89.2 to 116.8 mg/dL. The single-sample t-test was statistically significant (p = 0.000).

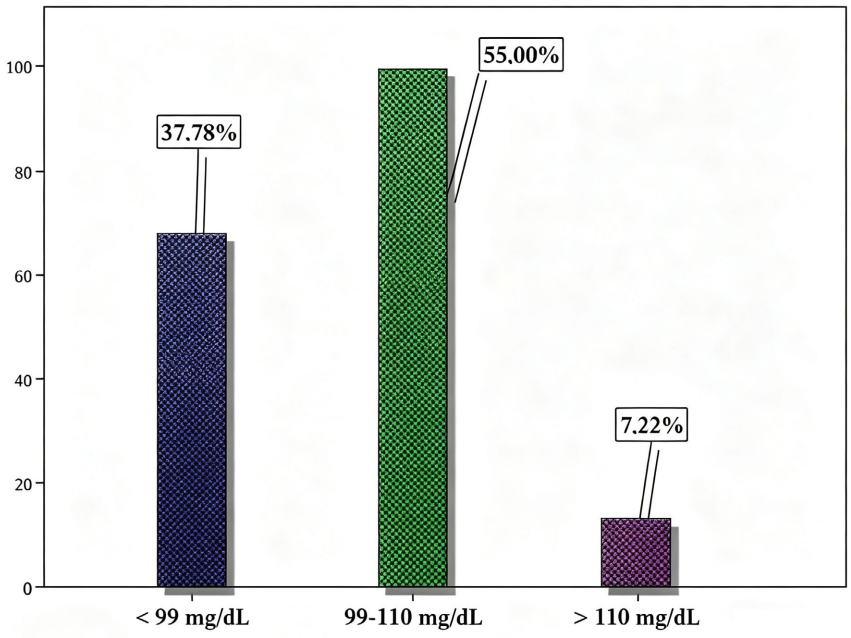

Figure 8. Distribution of cases according to chloremia levels.

Figure 9 shows that 21.67% of respondents had hypocalcemia and 10.56% had

hypercalcemia. The mean calcemia level was 8.9 ± 1 mg/dL, with a range of 5.9 - 12.6 mg/dL. The single-sample t-test was statistically significant (p = 0.000).

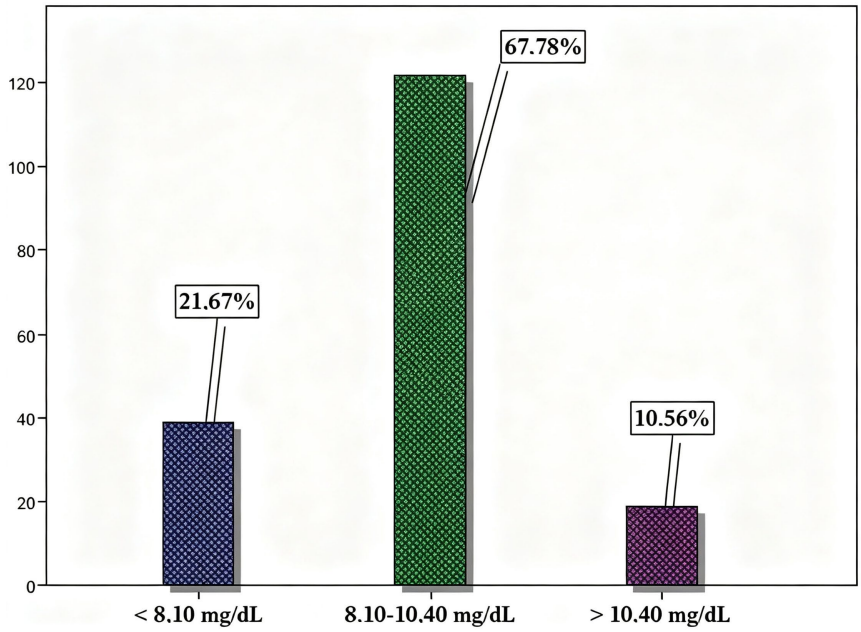

Figure 9. Distribution of cases according to calcemia levels.

Figure 10 shows that 5.56% of respondents had hypomagnesemia and 30.56% had hypermagnesemia. The mean magnesemia level was 2.2 ± 0.5 mg/dL, with extreme values ranging from 0.52 to 3.98 mg/dL. The single-sample t-test was statistically significant (p = 0.000).

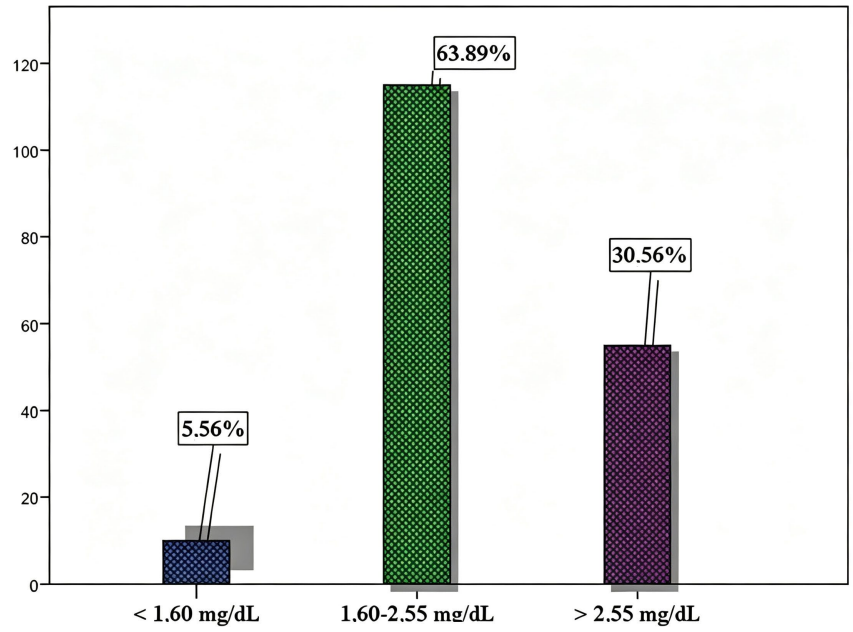

Figure 10. Distribution of cases according to magnesemia levels.

Figure 11 shows that 2.22% of respondents had hypophosphoremia and 32.78% had hyperphosphoremia. The mean phosphoremia level was 4.7 ± 1.3 mg/dL, with a range of 2.3 - 9.4 mg/dL. The single-sample t-test was statistically significant (p = 0.000).

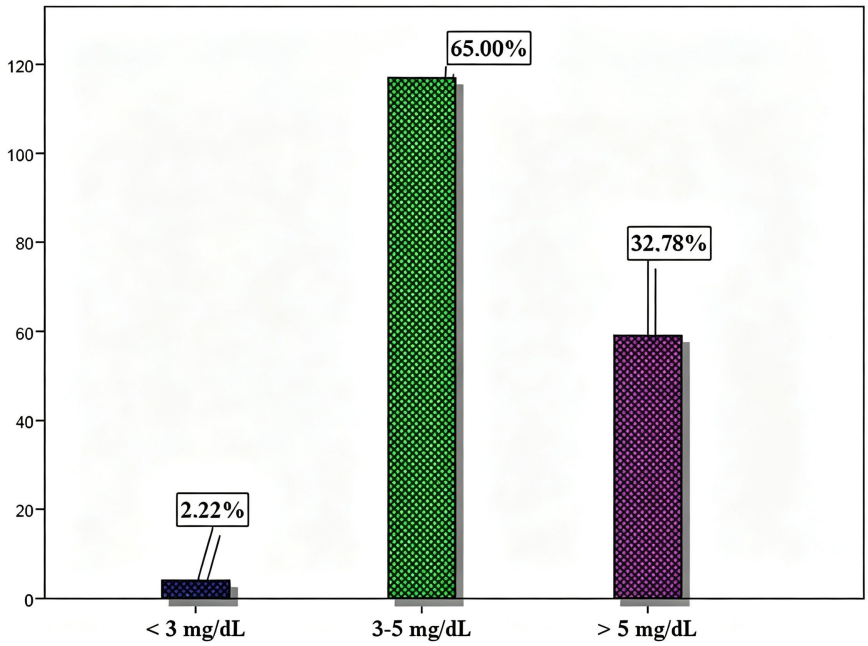

Figure 11. Distribution of cases according to phosphoremia levels.

Table 1. Evaluation of the Pearson's correlation between creatininemia levels and measured ion levels.

Creatininaemia/Ions	p-values
Calcemia (mg/dL)	p = 0.020
Chloremia (mg/dL)	p = 0.496
Kalemia (mmol/L)	p = 0.000
Magnesemia (mg/dL)	p = 0.000
Natremia (mmol/L)	p = 0.333
Phosphoremia (mg/dL)	p = 0.000
Total	**180**

Table 1 shows that there are statistically significant associations with calcemia, kalemia, magnesemia and phosphoremia levels, as p-values were less than 0.05. However, there are no statistically significant associations with natremia and chloremia levels, as p-values were greater than 0.05.

Table 2 shows that no statistically significant link was found between the sex of the respondents and the ions measured, since all p-values were greater than 0.05.

Table 2. Evaluation of the binary logistic regression between the sex of the respondents and the levels of measured ions.

Sex/Ions	p-values
Calcemia (mg/dL)	(OR = 1.162, [95% CI: 0.868 - 1.554], p = 0.314)
Chloremia (mg/dL)	(OR = 1.020, [95% CI: 0.961 - 1.084], p = 0.510)
Kalemia (mmol/L)	(OR = 1.119, [95% CI: 0.767 - 1.632], p = 0.559)
Magnesemia (mg/dL)	(OR = 1.030, [95% CI: 0.526 - 2.018], p = 0.931)
Natremia (mmol/L)	(OR = 0.995, [95% CI: 0.946 - 1.047], p = 0.859)
Phosphoremia (mg/dL)	(OR = 1.041, [95% CI: 0.817 - 1.327], p = 0.747)
Total	**180**

Table 3. Evaluation of the Pearson's correlation between the age of respondents and the levels of measured ions.

Age/Ions	p-values
Calcemia (mg/dL)	p = 0.829
Chloremia (mg/dL)	p = 0.300
Kalemia (mmol/L)	p = 0.432
Magnesemia (mg/dL)	p = 0.500
Natremia (mmol/L)	p = 0.846
Phosphoremia (mg/dL)	p = 0.220
Total	**180**

Table 3 shows that no statistically significant link was found between the age of the respondents and the ions measured, since all p-values were greater than 0.05.

4. Discussion

In this study, out of 180 patients with renal insufficiency, males (68.33%) were more numerous than females (31.67%). The sex ratio was 2.16 in favor of men (Figure 1). These results, with the male predominance, are similar to those found in the internal medicine department of the Abidjan military hospital, with a sex ratio of 2.88 [2]; in the internal medicine department of the Treichville University Hospital in Abidjan with a sex ratio of 1.3 [10]; in the United States with a sex ratio of 1.4 [11]; and in Côte d'Ivoire, Sudan, and Lubumbashi in the Democratic Republic of the Congo with 61%, 63%, and 55.5% of subjects being male, respectively [8] [12] [13]. This male predominance could be due to the fact that sex hormones play a major role in the initiation and progression of chronic kidney disease. Sex hormones are thought to be responsible for the progression of chronic kidney disease by influencing the synthesis and activity of cytokines and vasoactive agents, as well as the generation of reactive oxygen species and the production of matrix components [14]. Other epidemiological studies tend to show the role of toxic factors, particularly those of occupational origin, in the deterioration of

renal function, given that men are often exposed [15] [16]. The reduced number of women in chronic kidney disease populations is explained by the effects of estrogen, which confer a protective role on women against the progression of chronic kidney disease [14]. The evaluation of the binary logistic regression indicated that no statistically significant link was found between the sex of the respondents and the ions measured, since all p-values were greater than 0.05 (**Table 2**).

The average age of patients with renal insufficiency was 45 ± 18 years, ranging from 6 to 89 years. Those over 50 years of age were the most numerous (41.11%), followed by those aged 41 - 50 years (21.11%); we also observed young people around 18 years of age (7.22%) and 18 - 24 years of age (8.33%) among the cases. Thus, all age groups were affected (**Figure 2**). Other studies have also revealed the predominance of subjects over 50 years of age, while noting that the pathology affects all ages. [2] [7] [17]-[21]. This situation is caused by the aging of the nephrons [22] [23], as well as by high blood pressure, the use of alcohol, tobacco, indigenous products, and medicinal plants with energizing and aphrodisiac effects [20] [24]-[26]. It should be noted that the Pearson's correlation between age and the measured ions showed no statistically significant link, as all p-values were greater than 0.05 (**Table 3**).

80.56% of the subjects were from Lubumbashi; 8.89% from Kolwezi; 2.78% from Likasi; and others from other locations. Some came from other countries, notably Tanzania and South Africa, each representing 0.56% (**Figure 3**). This situation could be explained by the fact that patients residing in Lubumbashi had easier access to the surveyed healthcare facilities compared to those residing outside the city of Lubumbashi and the Democratic Republic of the Congo.

Renal exploration markers haveIt was shown that 97.22% of those surveyed had hyperuremia, with a mean uremia level of 162 ± 91 mg/dL and a range of 36.41 - 49.4 mg/dL. All (100%) had hypercreatininemia, with a mean creatininemia level of 7 ± 4 mg/dL and a range of 1.40 - 25.80 mg/dL. The single-sample t-test for both and creatininemia was statistically significant (p = 0.000) (**Figure 4** and **Figure 5**). In renal failure, elevated creatininemia levels can be observed with normal or elevated uremia [2] [26]; both of these biological parameters are always abnormal in all patients with renal failure [2] [26]-[28]. Pearson's correlation studies between serum creatinine and the analyzed ions revealed statistically significant associations at the significance level of p = 0.05 for calcemia (p = 0.020), kalemia (p = 0.000), magnesemia (p = 0.000), and phosphoremia (p = 0.000). However, no statistically significant associations were found with natremia (p = 0.333) and chloremia (p = 0.496) (**Table 1**). We focused on creatininemia because the creatininemia concentration is a key element in the biological assessment of renal failure, as it is used in calculating the estimated glomerular filtration rate, which is itself taken into account in the therapeutic intervention plan [29].

The measured ions revealed 50% hyponatremia; 44.44% of values within normal ranges and 5.56% hypernatremia; the mean natremia level was 135 ± 6 mmol/L, with extreme values ranging from 116.0 to 157.8 mmol/L. The single-sample t-test

was not statistically significant (p = 0.052) (**Figure 6**). Our hyponatremia data (50%) were significantly higher than those found by other authors, who confirmed that hyponatremia is often associated with chronic kidney disease and found 37.9%, 33%, and 6.8% of cases, respectively [30]-[32]. As for hypernatremia, other studies have found 12.6% of cases and suggest that hypernatremia could be attributed to the low-sodium diet [30].

Regarding kalemia, 12.78% of cases presented with hypokalemia, 55.27% with values within the normal range, and 30% with hyperkalemia. The mean kalemia level was 4 ± 9 mmol/L, with extreme values ranging from 2 to 7.6 mmol/L. The single-sample t-test was statistically significant (p = 0.000) (**Figure 7**). Hyperkalemia is one of the biological signs often associated with chronic kidney disease, especially in its advanced stages, and has been found in 39.1% [30] and 52.7% [31]. Elevated potassium is associated with acidosis due to excessive bicarbonate loss [33] [34]. One study found 2.2% hypokalemia [30], which is a low rate compared to our results.

Regarding chloremia levels, 37.78% of subjects had hypochloremia; 55% had values within the normal range, and 7.22% had hyperchloremia. The mean chloremia level was 100.7 ± 5 mg/dL, with extreme values ranging from 89.2 to 116.8 mg/dL. The single-sample t-test was statistically significant (p = 0.000) (**Figure 8**). Some authors have found 36% hyperchloremia and 23% hypochloremia [30]; and others have attributed hyperchloremia to the administration of excessive doses of parenteral saline solutions and hypochloremia to vomiting or diarrhea [35].

Following the calcemia level test, 21.67% of respondents had hypocalcemia; 67.78% with of values within normal ranges and 10.56% with hypercalcemia. The mean calcemia level was 8.9 ± 1 mg/dL, with extreme values ranging from 5.9 to 12.6 mg/dL. The single-sample t-test was statistically significant (p = 0.000) (**Figure 9**). Other sources have found hypocalcemia rates of 93.1% [30], 65.8% [32], and 58.47% [31], respectively. It should be noted that hypocalcemia is a major sign of chronic kidney disease and remains constant throughout the course of the disease due to impaired production of 1.25-dihydroxyvitamin D3 [30].

The magnesemia series revealed that 5.56% of subjects had hypomagnesemia; 63.89% had values within the normal range; and 30.56% had hypermagnesemia. The mean magnesemia level was 2.2 ± 0.5 mg/dL, with extreme values ranging from 0.52 to 3.98 mg/dL. The single-sample t-test was statistically significant (p = 0.000) (**Figure 10**). Other sources found 11.5% hypomagnesemia and 26.4% hypermagnesemia, noting that magnesium levels increase significantly in chronic kidney disease depending on the stage of the disease. Conversely, hypomagnesemia was observed following excessive renal losses [30].

Finally, phosphoremia levels revealed hypophosphoremia in 2.22% of cases, normal values in 65%, and hyperphosphoremia in 32.78%. The mean phosphoremia level was 4.7 ± 1.3 mg/dL, with a range of 2.3 - 9.4 mg/dL. The single-sample t-test was statistically significant (p = 0.000) (**Figure 11**). Other studies have found hyperphosphoremia in 71.3% of cases; and it should be added that disorders of

calcium and phosphore metabolism are common in chronic kidney disease due to the severity of the disease ($p < 0.05$) [30].

5. Conclusions

We observed that values below normal were seen in hyponatremia, hypochloremia, hypocalcemia and hypokalemia, with considerable levels. Conversely, lower values were observed in hypomagnesemia and hypophosphoremia.

Calcemia, phosphoremia, magnesemia, kalemia, and chloremia levels were more than 50% within normal ranges. Higher than normal levels were observed in hyperphosphoremia, hypermagnesemia, and hyperkalemia with significantly elevated levels. Conversely, lower than normal levels were seen in hypercalcemia, hyperchloremia, and hypernatremia.

Binary logistic regression between sex and measured ions, as well as Pearson correlation between age and measured ions, showed no statistically significant association. Only Pearson's correlation between serum creatinine and analyzed ions revealed statistically significant associations for calcemia, kalemia, magnesemia, and phosphoremia, but not for natremia and chloremia.

Therefore, electrolyte disturbances are common in renal failure and given their importance in the body, we recommend that clinicians take them into account when requesting biomedical analyses in this category of patients.

Author Contributions

All authors contributed identically to the different phases of the research.

Conflicts of Interest

The authors declare no conflicts of interest.

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