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Biochemical profiles of diabetic and/or hypertensive patients on hemodialysis at the Camp Lufungula Hemodialysis Center in Kinshasa: a retrospective study from January 2019 to June 2024

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Abstract

Background

In the Democratic Republic of the Congo (DRC), end-stage renal disease (ESRD) is predominantly driven by hypertension (HTN) and type 2 diabetes mellitus (T2DM). Out-of-pocket health expenditure leads to severe underdialysis and profound biochemical derangements. This study aimed to describe and compare the biochemical, electrolyte, and acid–base profiles of hemodialysis patients at the Camp Lufungula Hemodialysis Center in Kinshasa according to their underlying etiology (HTN vs. T2DM vs. HTN/T2DM).

Methods

A retrospective, descriptive, and comparative study was conducted at the Camp Lufungula Hemodialysis Center. Data were collected from 1 February to 1 April 2025 using a standardized questionnaire, exhaustively including 502 medical records of patients who underwent hemodialysis between January 2019 and June 2024. Intergroup comparisons were performed using ANOVA or the Kruskal–Wallis test ($p < 0.05$).

Results

The cohort showed a male predominance (67.3%; male-to-female ratio = 2.06) with a mean age of 51.93 ± 12.59 years. Isolated HTN accounted for 64.7% of cases, HTN/T2DM comorbidity for 27.5%, and isolated T2DM for 7.8%. The median number of dialysis sessions was 8. Serum creatinine was significantly higher in hypertensive patients (median 14.70 mg/dL vs. 7.94 mg/dL in T2DM and 11.90 mg/dL in HTN/T2DM; $p < 0.001$). Metabolic acidosis was severe, with markedly lower serum bicarbonate in the HTN/T2DM group (7.30 ± 5.25 mmol/L vs. 18.37 ± 18.13 mmol/L in HTN and 15.56 ± 11.95 mmol/L in T2DM; $p < 0.01$). Hypocalcemia affected 75.4% to 85.7% of patients, hyperkalemia predominated in patients with HTN/T2DM (46.4%), and anemia affected approximately 80% of the population.

Conclusions

Hemodialysis patients exhibit severe acid–base and electrolyte disorders, which are exacerbated by HTN/T2DM comorbidity and underdialysis. Optimizing dialysate composition and removing financial barriers are essential to improving their clinical management.

I. Background

End-stage renal disease (ESRD) is a major and growing public health problem worldwide, characterized by high morbidity and mortality and a considerable economic burden related to renal replacement therapy [1, 2].

Worldwide, the rising incidence of ESRD is driven by the epidemiological transition and the exponential growth of noncommunicable diseases, foremost diabetes mellitus and hypertension (HTN) [2, 3]. The World Health Organization (WHO) estimates that the global prevalence of diabetes in adults increased from 7% in 1990 to 14.1% in 2022, affecting approximately 830 million people [4]. The coexistence of HTN and diabetes accelerates nephroangiosclerosis and diabetic nephropathy, which together account for more than 50% of the underlying causes of ESRD requiring chronic hemodialysis [1, 3, 5–13].

In hemodialysis patients, these underlying diseases induce profound metabolic and biochemical disturbances [14, 15]. Electrolyte disorders, foremost hyperkalemia (frequently exacerbated by diabetic nephropathy and renin–angiotensin–aldosterone system inhibitors) [16], combined with chronic kidney disease–mineral and bone disorder (CKD-MBD) [17–19], critically increase the risk of fatal cardiovascular events. In addition, the quality of urea clearance—assessed by Daugirdas' logarithmic Kt/V kinetics [20]—and the control of systemic inflammation are major biochemical determinants of long-term survival [21, 22].

In Africa, the prevalence of diabetes and HTN is growing faster than in any other WHO region, with more than 54 million adults living with diabetes (over 50% undiagnosed) [4] and an HTN prevalence exceeding 40% of the adult population [23]. In contrast to industrialized countries, this dual etiological burden is fueling an ESRD epidemic affecting young and economically active individuals [23–25].

In sub-Saharan Africa, access to renal replacement therapy remains extremely limited (generally fewer than 20 patients per million population) [26], despite an estimated underlying prevalence of chronic kidney disease (CKD) of 13.9% to 18.0% [23, 27]. Care is hindered by fragile infrastructure, the absence of effective early prevention programs [28], and the prohibitive cost of treatment [24]. Fewer than 10% of patients reaching ESRD gain sustained access to hemodialysis, and more than 80% die or interrupt treatment prematurely because of financial constraints [24, 26, 29]. This chronic underdialysis (often limited to one or two sessions per week instead of the recommended three) perpetuates severe biochemical disorders, a malnutrition–inflammation syndrome, and refractory HTN [21, 24, 30, 31].

In the DRC, a country of more than 100 million inhabitants, fewer than 1,000 individuals are estimated to receive chronic hemodialysis, concentrated in a few urban facilities [32]. The absence of fully operational universal health coverage forces patients to pay directly for sessions (unit cost ranging from USD 150 to 250) [33].

In Kinshasa, the prevalence of CKD in the general adult population reaches 12.4% [34, 35], with HTN (30–38%) and type 2 diabetes mellitus (T2DM) (7–10%) being the main risk factors and causes of dialysis initiation [34–36]. The Camp Lufungula Hemodialysis Center is a strategic hospital facility providing care

to the civilian and military populations of the capital. However, out-of-pocket payment affects the regularity of biological monitoring and the frequency of dialysis sessions in these patients [33].

Although the seminal work of Sumaili et al. documented the general epidemiological profile and burden of CKD in Kinshasa [34, 35], up-to-date data on the dynamics of the biochemical profile (nitrogenous parameters, glycemic balance, serum electrolytes, calcium–phosphate balance, and acid–base status) are lacking, specifically for diabetic and/or hypertensive patients undergoing hemodialysis between January 2019 and June 2024. The absence of such local data hinders accurate cardiovascular risk stratification, individualized adaptation of dialysate baths, and the formulation of therapeutic recommendations suited to the sub-Saharan context. The present retrospective study was conducted to fill this gap by analyzing the characteristics and evolution of these biochemical parameters at the Camp Lufungula Hemodialysis Center in Kinshasa.

Research questions

The main research question was: what are the biochemical profiles of diabetic and/or hypertensive patients on hemodialysis at the Camp Lufungula Hemodialysis Center in Kinshasa? The secondary questions were:

- Are there statistically significant differences in biochemical parameters (glucose, electrolytes, urea, creatinine) between diabetic and hypertensive patients on hemodialysis?
- How do biochemical parameters evolve over time in diabetic and/or hypertensive patients on hemodialysis?
- Is there an association between certain biochemical parameters and the duration of hemodialysis in these patients?

Hypotheses

We hypothesized that diabetic and/or hypertensive patients on hemodialysis at the Camp Lufungula Hemodialysis Center present specific biochemical profiles characterized by metabolic and electrolyte disturbances related to their comorbidities and to chronic kidney failure. Specifically, we hypothesized that (i) biochemical parameters (glucose, electrolytes, urea, creatinine) differ significantly between diabetic and hypertensive patients; (ii) biochemical parameters vary significantly over time; and (iii) certain biochemical parameters are significantly associated with the duration of hemodialysis.

Objectives

The primary objective was to describe the biochemical profiles of diabetic and hypertensive patients on hemodialysis at the Camp Lufungula Hemodialysis Center in Kinshasa. The specific objectives were:

- To determine the mean values and distributions of the main biochemical parameters (glucose, urea, creatinine, electrolytes [sodium, potassium, calcium], and bicarbonate) in diabetic and/or hypertensive patients on hemodialysis;

- To compare biochemical profiles between patient groups (diabetic vs. hypertensive);
- To explore potential associations between hemodialysis duration and biochemical parameters within each group.

Significance of the study

Clinically, the results may help physicians better understand the specific challenges faced by these patients and adapt management strategies (dialysate adjustment, medication management, nutritional interventions). Epidemiologically, the study contributes to characterizing patients with diabetes- and hypertension-related ESRD in an African setting where data are often limited. For research, the findings may serve as a basis for further studies aimed at identifying risk factors for specific complications and evaluating the impact of therapeutic interventions on biochemical profiles and clinical outcomes. For public health, a better understanding of these profiles may inform health policies aimed at improving the management of CKD and its complications in diabetic and/or hypertensive patients in the DRC.

II. Methods

Study design and setting

This was a retrospective, descriptive, and comparative study based on data collected with a questionnaire from the records of patients who underwent hemodialysis sessions at the Camp Lufungula Hemodialysis Center between January 2019 and June 2024. Sampling was exhaustive. Data collection took place over a two-month period, from 1 February to 1 April 2025.

Study population

The study population comprised all diabetic and/or hypertensive patients who received hemodialysis sessions at the Camp Lufungula Hemodialysis Center in Kinshasa between January 2019 and June 2024.

Inclusion criteria:

- Patients of any age who requested hemodialysis;
- Confirmed diagnosis of ESRD requiring regular hemodialysis at the Camp Lufungula center;
- Confirmed diagnosis of diabetes (type 1 or type 2) or HTN (primary or secondary);
- Availability of relevant biochemical data in the medical records.

Exclusion criteria:

- Patients with ESRD due to other primary etiologies (e.g., glomerulonephritis, polycystic kidney disease);
- Incomplete medical records with missing biochemical data for the variables of interest.

Data collection

Data were retrospectively extracted from the medical records of eligible patients. The following information was collected: (i) demographic data (age, sex); (ii) medical history (type and duration of diabetes, type and duration of HTN, other comorbidities); and (iii) duration of hemodialysis. Biochemical parameters measured routinely before and/or during hemodialysis sessions were glucose, urea, creatinine, uric acid, hemoglobin, C-reactive protein (CRP), electrolytes (Na^+, K^+, Ca^{2+}, HCO_3^-, phosphorus, chloride), blood gases (PO_2, PCO_2), and pH. The operational definitions of the patient categories and the reference values used for the biochemical parameters are presented in Tables 1 and 2, respectively.

Table 1
Criteria defining the patient categories

Variable	Operational definition	Reference
Hypertensive patient (HTN)	Patient with a documented medical diagnosis of arterial hypertension in the medical record or receiving antihypertensive treatment, regardless of the blood pressure values on the day of assessment.	ESC/ESH 2023
Diabetic patient (T2DM)	Patient with a confirmed diagnosis of type 2 diabetes mellitus according to ADA criteria (fasting plasma glucose ≥ 126 mg/dL, HbA1c ≥ 6.5%, random plasma glucose ≥ 200 mg/dL with symptoms, or antidiabetic treatment).	ADA 2025
HTN + T2DM	Patient with a simultaneous confirmed diagnosis of arterial hypertension and type 2 diabetes mellitus.	ADA 2025; ESC 2023
End-stage renal disease (ESRD)	Glomerular filtration rate < 15 mL/min/1.73 m² or need for renal replacement therapy (chronic hemodialysis).	KDIGO 2024
Chronic hemodialysis patient	Patient receiving regular hemodialysis (≥ 2–3 sessions/week) for at least 3 months.	KDOQI 2020

ADA, American Diabetes Association; ESC/ESH, European Society of Cardiology/European Society of Hypertension; KDIGO, Kidney Disease: Improving Global Outcomes; KDOQI, Kidney Disease Outcomes Quality Initiative.

Table 2
Reference values and criteria defining abnormalities of the biochemical parameters

Parameter	Normal values	Definition of abnormalities
Glucose	70–99 mg/dL (fasting)	Hyperglycemia ≥ 126 mg/dL; hypoglycemia < 70 mg/dL
Creatinine	Men: 0.7–1.3 mg/dL Women: 0.6–1.1 mg/dL	Hypercreatininemia > 1.3 mg/dL (men) or > 1.1 mg/dL (women)
Urea	15–45 mg/dL	Hyperuremia > 45 mg/dL
Uric acid	Men: 3.5–7.2 mg/dL Women: 2.6–6.0 mg/dL	Hyperuricemia > 7 mg/dL (men) or > 6 mg/dL (women)
Sodium	135–145 mmol/L	Hyponatremia < 135 mmol/L; hypernatremia > 145 mmol/L
Potassium	3.5–5.0 mmol/L	Hypokalemia < 3.5 mmol/L; hyperkalemia > 5.0 mmol/L
Total calcium	2.20–2.60 mmol/L	Hypocalcemia < 2.20 mmol/L; hypercalcemia > 2.60 mmol/L
Phosphorus	2.5–4.5 mg/dL	Hyperphosphatemia > 4.5 mg/dL
Chloride	98–107 mmol/L	Hypochloremia < 98 mmol/L; hyperchloremia > 107 mmol/L
Bicarbonate (HCO_3^-)	22–26 mmol/L	Metabolic acidosis if HCO_3^- <22 mmol/L
Blood pH	7.35–7.45	Acidemia < 7.35; alkalemia > 7.45
$PaCO_2$	35–45 mmHg	Hypocapnia < 35 mmHg; hypercapnia > 45 mmHg
PaO_2	80–100 mmHg	Hypoxemia < 80 mmHg
Hemoglobin	Men: 13–17 g/dL Women: 12–16 g/dL	Anemia: Hb < 13 g/dL (men) or < 12 g/dL (women). In CKD, anemia is generally defined using these KDIGO thresholds.
CRP	< 5 mg/L	Inflammatory syndrome if CRP > 5 mg/L

CKD, chronic kidney disease; CRP, C-reactive protein; Hb, hemoglobin; $PaCO_2$, partial pressure of carbon dioxide; PaO_2, partial pressure of oxygen.

Laboratory analysis

Samples were analyzed using automated biochemistry analyzers.

Statistical analysis

Data were entered and analyzed using Microsoft Excel 2010 and SPSS version 23. Descriptive statistics (means, standard deviations, medians, quartiles, frequencies, and percentages) were used to summarize the demographic characteristics and biochemical profiles of the patient groups. Comparative tests (Student's t test, ANOVA, and the Kruskal–Wallis test for continuous variables; the chi-square test or Fisher's exact test for categorical variables) were used to compare biochemical profiles between patient groups. Correlations between continuous variables were expressed as correlation coefficients (ρ). A p-value < 0.05 was considered statistically significant.

Ethical considerations

The study was approved by the Bioethics Committee of the Institut Supérieur des Techniques Médicales de Kinshasa (authorization No. 0241/CBE/ISTM/KIN/RDC/PMBBL/2024 of 22 December 2024) before data collection began. Informed consent was obtained from the archive managers of the Camp Lufungula Hemodialysis Center. Patient anonymity and data confidentiality were strictly respected.

Definition of the main biological disturbances

The criteria used to define the main biological disturbances analyzed in this study are summarized in Table 3.

Table 3
Definition of the main biological disturbances

Disturbance	Criterion
Hyponatremia	Na^+ <135 mmol/L
Hypernatremia	Na^+ >145 mmol/L
Hypokalemia	K^+ <3.5 mmol/L
Hyperkalemia	K^+ >5.0 mmol/L
Hypocalcemia	Ca^{2+} <2.20 mmol/L
Hyperphosphatemia	Phosphorus > 4.5 mg/dL
Metabolic acidosis	pH < 7.35 with HCO_3^- <22 mmol/L
Hyperuremia	Urea > 45 mg/dL
Hypercreatininemia	Creatinine above the sex-specific reference values
Hyperuricemia	Uric acid > 7 mg/dL (men) or > 6 mg/dL (women)
Anemia	Hb < 13 g/dL (men) or < 12 g/dL (women)

III. Results

Sociodemographic characteristics

A total of 502 patients were included. Their sociodemographic characteristics are presented in Table 4. Men accounted for 67.3% of the cohort (n = 338), giving a male-to-female ratio of 2.06 ($p < 0.001$). The mean age was 51.93 ± 12.59 years (95% CI: 50.01–53.85), with 70.5% of patients aged between 43 and 72 years ($p < 0.001$). The median duration of HTN was 5 years, the median duration of T2DM was 10 years, and the median number of dialysis sessions was 8.

Table 4
Sociodemographic characteristics of the hemodialysis patients (N = 502)

Variable	n	%	Statistics	p-value
Sex				
Male	338	67.3	Male-to-female ratio = 2.06	< 0.001
Female	164	32.7		
Age group (years)				
13–22	18	3.59		
23–32	34	6.78		
33–42	64	12.75		
43–52	106	21.12		
53–62	158	31.47		
63–72	90	17.93		
73–82	30	5.97		
≥ 83	2	0.39		< 0.001
Age (years)			51.93 ± 12.59 (95% CI: 50.01–53.85)	
HTN duration (years)			Median: 5 (1–9)	
T2DM duration (years)			Median: 10 (5–15)	
Number of dialysis sessions			Median: 8 (1–15)	

CI, confidence interval; HTN, hypertension; T2DM, type 2 diabetes mellitus.

Clinical and epidemiological characteristics

Table 5 shows the distribution of patients by clinical category. Isolated HTN was by far the most frequent category (64.74%; n = 325), whereas isolated T2DM was uncommon (7.77%; n = 39). More than a quarter of the patients (27.49%; n = 138) had both conditions (p < 0.001). Mean blood pressure was 149 mmHg systolic and 88 mmHg diastolic.

Table 5
Clinical and epidemiological characteristics of the patients

Variable	n	%	p-value
HTN	325	64.74	
T2DM	39	7.77	
HTN/T2DM	138	27.49	< 0.001
Mean blood pressure			
Systolic	149 mmHg		
Diastolic	88 mmHg		

HTN, hypertension; T2DM, type 2 diabetes mellitus.

Figure 1 shows the distribution of the clinical categories by year. HTN remained the leading and most constant category throughout the study period (60.0% to 71.9% of patients per year, including 69.0% in 2023). The HTN/T2DM association ranked second (18.2% to 33.3%), while isolated T2DM remained a minority (3.1% to 15.2%). The distribution of the categories varied significantly across years (chi-square test, $p < 0.05$).

Overall biochemical profile

The biochemical parameters of the whole cohort and according to clinical category are shown in Table 6. Renal function was profoundly impaired, with a mean urea of 224.3 ± 110.6 mg/dL and a median creatinine of 13.6 mg/dL (Q1–Q3: 8.4–20.8). Creatinine differed significantly between the groups ($p < 0.001$), with the highest values in patients with isolated HTN. Marked metabolic acidosis was present (median bicarbonate 13.00 mmol/L), with a significant difference between groups ($p = 0.006$) and the highest values in the T2DM group. Severe anemia (mean hemoglobin 8.32 ± 2.68 g/dL) and a pronounced systemic inflammatory state (median CRP 77.98 mg/L) were observed in the cohort as a whole; CRP did not differ significantly between groups ($p = 0.179$), nor did uric acid ($p = 0.441$).

Table 6
Biochemical parameters of the hemodialysis patients according to clinical category and statistical distribution

Parameter	Distribution	All patients (N = 502)	HTN	T2DM	HTN/T2DM	Statistical test	p-value
Creatinine (mg/dL)	Non-normal	13.6 (8.4–20.8)	14.70 (10.20–22.20)	7.94 (6.52–12.03)	11.90 (7.55–16.78)	Kruskal–Wallis	< 0.001
Urea (mg/dL)	Normal	224.3 ± 110.6	—	—	—	ANOVA	—
Uric acid (mg/dL)	Non-normal	6.00 (2.97–9.65)	7.20 (3.60–10.00)	4.60 (3.20–6.00)	6.35 (2.18–8.60)	Kruskal–Wallis	0.441
Sodium (mmol/L)	Normal	131.23 ± 19.82	—	—	—	ANOVA	—
Potassium (mmol/L)	Normal	4.11 ± 2.03	—	—	—	ANOVA	—
Calcium (mmol/L)	Normal	1.31 ± 1.41	—	—	—	ANOVA	—
Chloride (mmol/L)	Normal	100.23 ± 28.90	—	—	—	ANOVA	—
Phosphorus (mg/dL)	Normal	5.10 ± 2.61	—	—	—	ANOVA	—
Bicarbonate (mmol/L)	Non-normal	13.00 (9.20–20.00)*	13.00 (9.20–20.00)	18.90 (14.63–20.35)	11.10 (7.08–16.60)	Kruskal–Wallis	0.006
pH	Normal	7.28 ± 0.61	—	—	—	ANOVA	—
PO_2 (mmHg)	Normal	107.7 ± 54.4	—	—	—	ANOVA	—
PCO_2 (mmHg)	Normal	26.45 ± 15.49	—	—	—	ANOVA	—
Hemoglobin (g/dL)	Normal	8.32 ± 2.68	—	—	—	ANOVA	—
CRP (mg/L)	Non-normal	77.98 (12.00–175.00)*	77.98 (12.00–175.00)	96.00 (24.35–187.45)	77.90 (9.41–125.09)	Kruskal–Wallis	0.179

Parameter	Distribution	All patients (N = 502)	HTN	T2DM	HTN/T2DM	Statistical test	p-value
Glucose (mg/dL)	Normal	111.25 ± 108.70	—	—	—	ANOVA	—

Normally distributed variables are expressed as mean ± SD (ANOVA or Student's t test); non-normally distributed variables are expressed as median (Q1–Q3) (Kruskal–Wallis test). *Median for the whole cohort. —, group-specific values for normally distributed variables are given in Tables 7–9. CRP, C-reactive protein; HTN, hypertension; SD, standard deviation; T2DM, type 2 diabetes mellitus.

Comparison of biochemical parameters between patient categories

Group comparisons are presented in Tables 7 and 8. Glucose differed markedly between groups ($p < 0.001$), with severe hyperglycemia in the T2DM group (232.94 mg/dL) and lower values in the HTN group. Renal function was more severely impaired in hypertensive patients: creatinine ($p < 0.001$) and urea ($p = 0.045$) were highest in the HTN group, with urea also high in the HTN/T2DM group. Bicarbonate concentrations were significantly different between groups ($p = 0.006$), with the lowest mean in the HTN/T2DM group (7.30 ± 5.25 mmol/L). Uric acid ($p = 0.441$) and CRP ($p = 0.179$) did not differ significantly between groups, although CRP values were high overall.

Table 7
Comparison of biochemical parameters according to patient category

Parameter	HTN (n = 325)	T2DM (n = 39)	HTN/T2DM (n = 138)	Presentation	p-value
Normally distributed variables					
Glucose (mg/dL)	67.52 ± 75.21	232.94 ± 142.81	146.60 ± 100.82	Mean ± SD	< 0.001
Urea (mg/dL)	219.43 ± 108.12	159.43 ± 90.33	221.39 ± 130.85	Mean ± SD	0.045
HCO_3^- (mmol/L)	18.37 ± 18.13	15.56 ± 11.95	7.30 ± 5.25	Mean ± SD	0.006
Non-normally distributed variables					
Creatinine (mg/dL)	14.70 (10.20–22.20)	7.94 (6.52–12.03)	11.90 (7.55–16.78)	Median (Q1–Q3)	< 0.001
Uric acid (mg/dL)	7.20 (3.60–10.00)	4.60 (3.20–6.00)	6.35 (2.18–8.60)	Median (Q1–Q3)	0.441
CRP (mg/L)	77.98 (12.00–175.00)	96.00 (24.35–187.45)	77.90 (9.41–125.09)	Median (Q1–Q3)	0.179

Normally distributed variables were compared by ANOVA (or Student's t test) and non-normally distributed variables by the Kruskal–Wallis test; significance threshold $p < 0.05$. Median bicarbonate values (Q1–Q3) are given in Table 6. CRP, C-reactive protein; HTN, hypertension; SD, standard deviation; T2DM, type 2 diabetes mellitus.

Among the electrolytes (Table 8), phosphorus was the only parameter that differed significantly between groups ($p = 0.011$), with the highest mean in the T2DM group (5.15 mg/dL) and the lowest in the HTN/T2DM group (4.58 mg/dL). Calcium showed a borderline trend ($p = 0.056$), with mean values increasing progressively from the HTN group to the HTN/T2DM group. Sodium and chloride did not differ significantly ($p = 0.56$ for both); the HTN/T2DM group had numerically lower sodium and chloride, whereas the T2DM group had the highest chloride. Potassium was comparable across groups ($p = 0.69$), with a slight numerical tendency toward lower values in the HTN group.

Table 8
Comparison of serum electrolytes according to patient category (mean ± SD)

Parameter	HTN	T2DM	HTN/T2DM	p-value
Sodium (mmol/L)	129.44 ± 20.21	132.16 ± 15.26	124.98 ± 39.20	0.56
Potassium (mmol/L)	3.32 ± 2.05	4.05 ± 2.24	3.90 ± 2.41	0.69
Calcium (mmol/L)	1.16 ± 0.97	1.32 ± 0.27	1.45 ± 1.87	0.056
Chloride (mmol/L)	93.24 ± 36.06	114.83 ± 14.11	86.59 ± 48.39	0.56
Phosphorus (mg/dL)	4.72 ± 2.23	5.15 ± 2.61	4.58 ± 3.04	0.011

HTN, hypertension; SD, standard deviation; T2DM, type 2 diabetes mellitus.

Blood gases and fluid–electrolyte and acid–base disturbances

Blood gases and the frequency of fluid–electrolyte and acid–base disturbances are shown in Table 9. PO_2, PCO_2, and pH were comparable between groups, whereas bicarbonate differed significantly ($p < 0.01$), with the lowest value in the HTN/T2DM group (7.30 mmol/L), in which metabolic acidosis was also frequent (33.3%, vs. 27.3% in HTN and 5.3% in T2DM). Hypocalcemia was widespread, affecting 75.4% to 85.7% of patients across the three groups. Hyponatremia was very common, particularly in the HTN group (54.7%). Potassium disorders showed a contrasting pattern: hypokalemia was most frequent in the T2DM group (36.8%), whereas hyperkalemia predominated in the combined HTN/T2DM group (46.4%). Hyperphosphatemia was rare in all groups. Overall, the HTN/T2DM association was characterized by the most severe acid–base and potassium disturbances.

Table 9
Blood gases and fluid–electrolyte and acid–base disturbances according to patient category

Parameter	HTN	T2DM	HTN/T2DM	p-value
Blood gases (mean ± SD)				
PO_2 (mmHg)	108 ± 56.2	91.33 ± 47.54	115.72 ± 68.89	0.28
PCO_2 (mmHg)	26.81 ± 22.1	24.46 ± 8.07	17.95 ± 8.97	0.67
HCO_3^- (mmol/L)	18.37 ± 18.13	15.56 ± 11.95	7.30 ± 5.25	< 0.01
pH	7.17 ± 1.07	7.26 ± 0.41	7.31 ± 0.16	0.30
Fluid–electrolyte and acid–base disturbances, n (%)				
Hyponatremia	176 (54.7)	14 (36.8)	58 (42.0)	—
Hypernatremia	28 (8.7)	2 (5.3)	16 (11.6)	—
Hypokalemia	30 (9.3)	14 (36.8)	12 (8.7)	—
Hyperkalemia	106 (32.9)	12 (31.6)	64 (46.4)	—
Hypocalcemia	276 (85.7)	32 (84.2)	104 (75.4)	—
Hyperphosphatemia	6 (1.9)	0 (0)	2 (1.4)	—
Metabolic acidosis	88 (27.3)	2 (5.3)	46 (33.3)	—

HTN, hypertension; SD, standard deviation; T2DM, type 2 diabetes mellitus.

Renal and hematological disturbances

Table 10 summarizes the renal and hematological disturbances. Hyperuremia and hypercreatininemia affected almost the entire cohort (91.3% to 100% depending on the group), reflecting severe renal impairment across all categories. Anemia was a major shared complication, present in 68.4% of the T2DM group and in nearly 80% of the HTN and HTN/T2DM groups. In contrast, hyperuricemia was infrequent (0% to a maximum of 8.7% in the combined group).

Table 10
Renal and hematological disturbances according to patient category, n (%)

Disturbance	HTN	T2DM	HTN/T2DM
Hyperuremia	306 (95.0)	38 (100)	126 (91.3)
Hypercreatininemia	312 (96.9)	38 (100)	134 (97.1)
Hyperuricemia	14 (4.3)	0 (0)	12 (8.7)
Anemia (Hb < 12 g/dL)	256 (79.5)	26 (68.4)	110 (79.7)

Hb, hemoglobin; HTN, hypertension; T2DM, type 2 diabetes mellitus.

Follow-up according to the number of hemodialysis sessions

The trends in biochemical parameters according to the number of hemodialysis sessions received are summarized in Table 11. A higher number of sessions was associated with a progressive decrease in urea, whereas creatinine and uric acid decreased only moderately or partially and remained elevated. Hyperkalemia tended to normalize and sodium to stabilize, and the increase in bicarbonate and the return of pH toward normal indicated an improvement of the acid–base balance. In contrast, hypocalcemia improved only to a limited extent, and anemia showed only a slight improvement despite erythropoietin treatment.

Table 11
Trends in biochemical parameters according to the number of hemodialysis sessions received

Parameter	Low number of sessions	High number of sessions	Interpretation
Urea	Very high	Progressive decrease	Good dialysis clearance efficacy.
Creatinine	Very high	Moderate decrease	Reduction after dialysis, but values remain high in patients with chronic kidney failure.
Potassium	Frequent hyperkalemia	Progressive normalization	Effective correction by hemodialysis.
Sodium	Frequent hyponatremia	Stabilization	Partial correction, depending on fluid balance.
Bicarbonate (HCO_3^-)	Low	Increase	Correction of metabolic acidosis.
pH	Acidosis	Return toward normal	Improvement of the acid–base balance.
Calcium	Persistent hypocalcemia	Limited improvement	Also depends on vitamin D and phosphate binder treatment.
Hemoglobin	Marked anemia	Slight improvement	On EPO treatment, but anemia remains frequent.
Uric acid	High	Decrease	Partial removal by dialysis.

EPO, erythropoietin.

By patient category, diabetic patients appeared to be followed more closely, with a decrease in urea and creatinine and correction of acidosis, but with frequent persistence of anemia related to nephropathy. In hypertensive patients (the largest group), the fluid–electrolyte balance (potassium, sodium, bicarbonate) improved clearly, but urea and creatinine remained high, consistent with advanced renal failure. Patients with both T2DM and HTN had the most severe biological abnormalities and required a greater number of sessions to control fluid and sodium overload, hyperkalemia, and acidosis. Overall, a higher dialysis frequency globally improved clearance and acid–base and electrolyte balance, but certain chronic complications (anemia, calcium abnormalities) require additional targeted treatments.

Correlations and associations between biochemical parameters and clinical categories

Serum creatinine was positively correlated with urea ($\rho = 0.576$; $p < 0.001$) and potassium ($\rho = 0.220$; $p < 0.001$), and negatively correlated with calcium ($\rho = -0.295$; $p < 0.001$), hemoglobin ($\rho = -0.272$; $p < 0.001$), sodium ($\rho = -0.173$; $p < 0.001$), and age ($\rho = -0.302$; $p < 0.001$).

The associations between biochemical parameters and clinical categories are presented in Table 12. Creatinine ($p < 0.0001$), sodium ($p = 0.0234$), potassium ($p = 0.0093$), calcium ($p < 0.0001$), pH ($p = 0.0203$), and hemoglobin ($p = 0.0321$) differed significantly between categories. Renal function was severely impaired in all groups, but creatinine and potassium were higher in hypertensive patients (alone or combined with diabetes) than in patients with diabetes alone. Blood pH remained within the normal range in diabetes alone (7.41) but fell toward acidosis in hypertensive patients (7.26 in HTN and 7.30 in HTN/T2DM). Urea ($p = 0.2010$) and CRP ($p = 0.1108$) did not differ significantly, indicating similar levels of severe anemia and inflammation across all groups, regardless of the underlying condition.

Table 12
Associations between biochemical parameters and clinical categories (mean ± SD / median)

Parameter	HTN	T2DM	HTN/T2DM	p-value
Creatinine (mg/dL)	17.19 ± 17.96 / **14.80**	10.49 ± 7.13 / **8.47**	12.63 ± 6.52 / **11.90**	**< 0.0001**
Sodium (mmol/L)	131.02 ± 16.59 / **133.0**	135.31 ± 10.14 / **136.0**	132.05 ± 27.60 / **135.0**	**0.0234**
Potassium (mmol/L)	4.86 ± 1.33 / **4.70**	4.35 ± 1.48 / **4.20**	5.03 ± 1.53 / **5.10**	**0.0093**
Calcium (g/L)	1.22 ± 1.28 / **0.97**	1.24 ± 0.29 / **1.17**	1.59 ± 1.83 / **1.03**	**< 0.0001**
Blood pH	7.26 ± 0.75 / **7.34**	7.41 ± 0.32 / **7.46**	7.30 ± 0.12 / **7.31**	**0.0203**
Hemoglobin (g/dL)	8.18 ± 2.41 / **8.00**	8.05 ± 1.90 / **7.75**	8.68 ± 3.06 / **8.60**	**0.0321**
Urea (mg/dL)	232.26 ± 117.03 / **215.9**	211.67 ± 94.78 / **221.7**	208.13 ± 95.93 / **211.3**	0.2010 (NS)
CRP (mg/L)	90.22 ± 82.70 / **77.98**	117.48 ± 101.87 / **96.0**	81.23 ± 72.86 / **72.05**	0.1108 (NS)

Values are mean ± SD / median (median in bold). NS, not significant; CRP, C-reactive protein; HTN, hypertension; SD, standard deviation; T2DM, type 2 diabetes mellitus.

In summary, the combination of hypertension and diabetes appeared to worsen renal failure and the electrolyte and acid–base imbalances.

Temporal evolution of biochemical parameters, 2019–2024

The biological profile of patients admitted to hemodialysis over the study period showed significant trends (Table 13). Urea increased significantly over the years ($\rho = +0.137$; $p = 0.002$), from approximately 170 mg/dL in 2019 to more than 250 mg/dL in 2024. Calcium ($\rho = -0.182$; $p < 0.001$) and hemoglobin ($\rho = -0.160$; $p = 0.001$) decreased steadily and significantly, with calcium reaching its lowest value in 2024 and hemoglobin reaching 7.05 ± 2.32 g/dL, reflecting a worsening chronic anemia. CRP showed no significant linear trend over the years ($\rho = -0.007$; not significant), despite occasional year-to-year

variations. In summary, the 2019–2024 period was marked by a progressive deterioration in urea, calcium, and hematological status.

Table 13
Annual values of selected biochemical parameters and temporal trends, 2019–2024 (mean ± SD)

Year	Urea (mg/dL)	Calcium (g/L)	Hemoglobin (g/dL)	CRP (mg/L)
2019	170.14 ± 68.35	1.78 ± 2.05	8.60 ± 2.02	95.52 ± 77.95
2020	244.02 ± 105.08	1.49 ± 1.83	8.85 ± 2.47	84.00 ± 85.29
2021	222.66 ± 119.81	1.06 ± 0.44	8.61 ± 3.43	71.23 ± 73.88
2022	198.27 ± 104.24	1.50 ± 1.76	7.92 ± 1.71	141.63 ± 99.36
2023	246.80 ± 112.59	1.20 ± 1.09	8.05 ± 2.38	83.49 ± 68.90
2024	250.40 ± 123.55	0.85 ± 0.26	7.05 ± 2.32	63.12 ± 64.58
Trend (ρ)	**ρ = +0.137 (p = 0.002)**	**ρ = −0.182 (p < 0.001)**	**ρ = −0.160 (p = 0.001)**	ρ = −0.007 (NS)

ρ, correlation coefficient with year; NS, not significant; CRP, C-reactive protein; SD, standard deviation.

IV. Discussion

This study aimed to describe and compare the biochemical profiles of diabetic and/or hypertensive patients undergoing chronic hemodialysis at the Camp Lufungula Hemodialysis Center in Kinshasa. The analysis of 502 records covering the period 2019 to 2024 reveals a relatively young, predominantly male population in which HTN is the main comorbidity. The results also show substantial disturbances of nitrogen, glucose, mineral, and acid–base metabolism, together with hematological and inflammatory abnormalities. These observations are consistent with the high burden of ESRD in sub-Saharan Africa [1, 2, 14, 24, 27].

Sociodemographic characteristics of the patients

In our study, men represented 67.3% of patients, with a male-to-female ratio of 2.06. The mean age was 51.93 ± 12.59 years, and the 53–62 age group was the most represented (31.47%). This male predominance is comparable to that reported in several African series of hemodialysis patients. Kaze et al. notably described a predominantly male hemodialysis population in sub-Saharan Africa, with a marked accumulation of cardiovascular and metabolic risk factors [14]. Similar observations have been reported in studies of dialysis patients in West and Central Africa [22, 25].

The male predominance observed in our series may be related to several factors, including differences in exposure to cardiovascular risk factors, health-seeking behaviors, and diagnostic delays. However, this interpretation must remain cautious, because our retrospective study cannot establish that sex is in

itself an independent determinant of access to hemodialysis. It may also reflect the particular structure of the population attending the Camp Lufungula Hemodialysis Center.

The mean age of 51.93 years also indicates that end-stage kidney disease occurs at a relatively young age compared with some series from high-income countries. This is consistent with the epidemiological characteristics of CKD in sub-Saharan Africa, where patients frequently reach the terminal stage in a context of late diagnosis and limited access to specialized nephrology care [24, 27]. In the Kinshasa population, Sumaili et al. have already shown the importance of CKD and its cardiovascular and metabolic risk factors [34, 35].

Predominance of hypertension and its association with diabetes

HTN was the main condition found in our population, present in 64.74% of patients, followed by the HTN and type 2 diabetes association (27.49%), while isolated T2DM accounted for 7.77%. The predominance of HTN is consistent with data from several African populations of dialysis patients [14, 23, 25].

This high representation of HTN may be explained by its role as both a cause and a consequence of CKD. Chronic elevation of blood pressure causes progressive vascular and glomerular damage, while declining renal function in turn promotes sodium and water retention and activation of the renin–angiotensin–aldosterone system, contributing to the maintenance or worsening of hypertension [7, 8, 13]. In diabetic patients, chronic hyperglycemia and advanced glycation end products also contribute to the progression of kidney damage [9–12].

The large proportion of patients with both HTN and diabetes is particularly important clinically. The combination of these two conditions exposes patients to more complex kidney damage because of complementary pathophysiological mechanisms: glomerular hyperfiltration, neurohormonal activation, oxidative stress, inflammation, and microvascular injury [5–13]. In our series, this association also appeared to be accompanied by greater disturbances of certain parameters, notably bicarbonate and potassium.

Disturbances of nitrogen metabolism: urea and creatinine

Hyperuremia and hypercreatininemia were observed in almost all patients studied. Median serum creatinine was 14.70 mg/dL in hypertensive patients, 7.94 mg/dL in diabetic patients, and 11.90 mg/dL in patients with HTN/T2DM, with a statistically significant difference between groups ($p < 0.001$). Mean urea was also elevated, at 219.43 ± 108.12 mg/dL in hypertensive patients, 159.43 ± 90.33 mg/dL in diabetic patients, and 221.39 ± 130.85 mg/dL in HTN/T2DM patients ($p = 0.045$). These results are consistent with the terminal stage of kidney disease of the included patients and with the major reduction in renal excretion of nitrogenous catabolic products [1, 2, 15].

Elevated creatinine is expected in patients with end-stage renal disease, since glomerular filtration capacity is severely reduced. However, in hemodialysis patients, creatinine concentration does not depend solely on residual renal function. It is also influenced by muscle mass, nutritional status, the

interval between sessions, and the efficiency of extracorporeal clearance. Thus, a high creatinine value should not be interpreted in isolation as an indicator of dialysis efficacy or inefficacy.

The positive correlation observed in our study between creatinine and urea ($\rho = 0.576$; $p < 0.001$) reinforces the clustering of nitrogen metabolism markers. This association is physiologically plausible because the accumulation of these two products partly reflects reduced renal elimination. It may also be influenced by catabolic state, protein intake, and dialysis efficiency [2, 20].

Glycemic profile and influence of diabetes

Glucose was one of the parameters showing the clearest intergroup difference. Diabetic patients had a mean glucose of 232.94 ± 142.81 mg/dL, compared with 67.52 ± 75.21 mg/dL in hypertensive patients and 146.60 ± 100.82 mg/dL in HTN/T2DM patients ($p < 0.001$).

This difference logically reflects the influence of diabetes on glucose metabolism. Chronic hyperglycemia is not only a marker of poor metabolic control but also contributes to the progression of kidney damage through glomerular hyperfiltration, oxidative stress, advanced glycation end products, and activation of inflammatory pathways and the renin–angiotensin system [5–13].

The relatively high glucose in the HTN/T2DM group compared with the hypertensive group also confirms the importance of the diabetic component in the metabolic profile of these patients. Nevertheless, the interpretation of an isolated glucose value in a hemodialysis patient must take into account the timing of sampling relative to the session, food intake, antidiabetic treatment, and changes in insulin sensitivity associated with kidney failure.

Fluid and electrolyte disturbances

In our series, hyponatremia was a frequent abnormality, particularly in hypertensive patients, whereas hyperkalemia was relatively more frequent in patients with the HTN/T2DM association. Hypocalcemia was also a major abnormality, reaching 85.7% of hypertensive patients, 84.2% of diabetic patients, and 75.4% of HTN/T2DM patients.

These results are consistent with the classic fluid and electrolyte disturbances of end-stage renal disease. Reduced renal sodium excretion, variations in hydration status, and dialysis prescription may alter plasma sodium concentration. Likewise, potassium disorders result from the interaction between dietary intake, cellular catabolism, acid–base balance, medications, and the efficiency of extracorporeal clearance [15, 16].

The high frequency of hyperkalemia in the HTN/T2DM group is particularly relevant. Diabetes may contribute to reduced potassium excretion, and certain drugs acting on the renin–angiotensin–aldosterone system may increase the risk of hyperkalemia in patients with diabetic kidney disease [16]. However, the data available in our study do not allow us to assess separately the effect of antihypertensive or antidiabetic treatments.

Disturbances of calcium–phosphate metabolism

Phosphorus differed significantly between groups (p = 0.011), with mean concentrations of 4.72 ± 2.23 mg/dL in hypertensive patients, 5.15 ± 2.61 mg/dL in diabetic patients, and 4.58 ± 3.04 mg/dL in HTN/T2DM patients.

These observations fall within the framework of CKD-associated mineral and bone disorder (CKD-MBD). Reduced glomerular filtration leads to decreased phosphate excretion, impaired calcitriol synthesis, and secondary changes in the regulation of parathyroid hormone and FGF23 [17, 18]. These abnormalities may contribute to vascular calcification and increased cardiovascular risk in hemodialysis patients [17–19].

The hypocalcemia observed in our population is also compatible with these mechanisms. The high frequency of this abnormality underlines the importance of regular monitoring of calcium–phosphate parameters in hemodialysis patients, particularly in a context where access to specialized tests may be limited.

Acid–base imbalance and bicarbonate

A significant difference in bicarbonate concentrations was observed between groups (p = 0.006). Mean bicarbonate was 18.37 ± 18.13 mmol/L in hypertensive patients, 15.56 ± 11.95 mmol/L in diabetic patients, and 7.30 ± 5.25 mmol/L in HTN/T2DM patients. The particularly low concentration in patients with both comorbidities suggests a greater acid–base imbalance in this group.

Metabolic acidosis is a frequent complication of advanced kidney failure. It results notably from reduced excretion of fixed acids and reduced renal capacity to regenerate bicarbonate. In dialysis patients, its magnitude also depends on the interdialytic interval, dialysis efficiency, and the bicarbonate concentration of the dialysate [2, 20, 21].

In our population, the frequency of metabolic acidosis was 27.3% in hypertensive patients and 33.3% in HTN/T2DM patients, compared with 5.3% in diabetic patients. These results are compatible with a significant acid–base imbalance in a substantial proportion of patients. The low bicarbonate in patients with both HTN and diabetes may reflect a greater metabolic complexity in this population. However, given the retrospective nature of the study and the absence of detailed information on the timing of sampling relative to the session, this interpretation must remain cautious.

Anemia in hemodialysis patients

The mean hemoglobin of the whole population was 8.32 ± 2.68 g/dL. Anemia affected 79.5% of hypertensive patients and 79.7% of those with the HTN/T2DM association, compared with 68.4% of patients with isolated diabetes.

The high frequency of anemia is consistent with the pathophysiology of end-stage renal disease. Reduced renal erythropoietin production is the main mechanism, to which are added chronic inflammation, nutritional deficiencies, blood loss related to dialysis sessions, and sometimes functional iron deficiency. The association between kidney failure, inflammation, and malnutrition is particularly important in hemodialysis patients in sub-Saharan Africa [14, 21, 30].

The trend observed in our study toward decreasing hemoglobin over the years, reaching 7.05 g/dL in 2024, deserves particular attention. It may reflect a change in the clinical profile of patients admitted to the center, a longer delay in referral to dialysis, or difficulties in anemia management. However, this hypothesis cannot be confirmed by our study and would require a specific analysis including treatment with erythropoiesis-stimulating agents, iron status, and nutritional markers.

Inflammation and CRP

CRP was elevated in the whole population, with a median of 77.98 mg/L. Median values were 77.98 mg/L in hypertensive patients, 96.00 mg/L in diabetic patients, and 77.90 mg/L in HTN/T2DM patients, with no statistically significant difference between groups ($p = 0.179$).

The elevated CRP suggests marked inflammatory activation in this population. Chronic inflammation is common in hemodialysis patients and may be promoted by intercurrent infections, vascular access, comorbidities, oxidative stress, bioincompatibility of certain dialysis components, and malnutrition [21, 22, 30].

However, the absence of a statistically significant difference in CRP between the three groups indicates that inflammation does not appear to be exclusively related to diabetic or hypertensive status. It may reflect factors common to the entire hemodialysis population. This observation is consistent with data showing that inflammation is a transversal phenomenon in chronic hemodialysis patients [21, 22].

Relationships between creatinine and other biochemical parameters

Correlation analysis showed a positive association between creatinine and urea ($\rho = 0.576$; $p < 0.001$), as well as between creatinine and potassium ($\rho = 0.220$; $p < 0.001$). Conversely, creatinine was negatively correlated with calcium ($\rho = -0.295$; $p < 0.001$), hemoglobin ($\rho = -0.272$; $p < 0.001$), sodium ($\rho = -0.173$; $p < 0.001$), and age ($\rho = -0.302$; $p < 0.001$).

The positive correlation between creatinine and urea is biologically coherent and reflects the clustering of markers of nitrogenous waste accumulation. The positive relationship with potassium may be explained by reduced renal potassium excretion and by the association between advanced renal failure and acid–base disturbances [2, 16].

The negative correlation between creatinine and calcium is also compatible with the disturbances of mineral metabolism observed in advanced CKD [17–19]. Similarly, the negative association between creatinine and hemoglobin may reflect the concomitant worsening of anemia with the degree of renal

impairment. However, these associations should not be interpreted as causal relationships, since several clinical and therapeutic factors may act simultaneously.

Evolution of biological parameters over the 2019–2024 period

The temporal analysis showed a significant increase in urea over the years ($\rho = +0.137$; $p = 0.002$), together with a decrease in hemoglobin ($\rho = -0.160$; $p = 0.001$) and calcium ($\rho = -0.182$; $p < 0.001$). Mean urea reached 250.40 ± 123.55 mg/dL in 2024, while mean hemoglobin fell to 7.05 ± 2.32 g/dL.

These trends may reflect a progressive change in the profile of patients treated, possibly with admission at a more advanced stage of the disease. African data indeed show that diagnostic delays and limited access to nephrology care contribute to late presentation at the terminal stage [24, 26–29].

However, the changes observed between 2019 and 2024 should not be automatically equated with individual worsening of patients. Our study is retrospective and concerns patients included in different years; annual variations may therefore reflect differences in the composition of the recruited populations, therapeutic practices, analytical methods, admission criteria, or the organization of the center. Individual longitudinal studies would be needed to confirm a true intra-individual evolution.

Contribution of the study in the Kinshasa context

One of the main strengths of this study is the description of a relatively large series of 502 hemodialysis patients in a Kinshasa center. The work of Sumaili et al. has already established the importance of CKD and its risk factors in the Kinshasa population [34, 35]. Our study complements it by characterizing the biochemical profile of a population that has reached end-stage renal disease and requires hemodialysis.

The results show that the patients treated present an accumulation of several abnormalities: disturbances of nitrogen metabolism, hyperglycemia in diabetic patients, fluid and electrolyte disorders, hypocalcemia, phosphate disturbances, metabolic acidosis, anemia, and inflammation. This combination of disturbances is particularly important in a context where access to renal replacement therapy remains limited in sub-Saharan Africa [24, 26, 27].

Regular monitoring of these parameters is therefore an essential element of management. Monitoring of urea and creatinine should be complemented by the assessment of potassium, calcium, phosphorus, bicarbonate, hemoglobin, and inflammatory markers in order to identify early the complications likely to affect patient prognosis.

Limitations of the study

This study has several limitations that should be taken into account when interpreting the results. First, its retrospective nature exposes it to the risk of missing data and selection bias. Second, the study was conducted in a single dialysis center, which limits the generalizability of the results to all hemodialysis patients in Kinshasa or the DRC.

Third, several parameters likely to strongly influence biochemical results, notably the dialysis dose, Kt/V, dialysate bath concentrations, antihypertensive and antidiabetic treatments, iron status, erythropoietin treatment, and nutritional status, were not systematically available in the analyzed data. Finally, the associations observed in the correlation analysis do not allow a causal relationship to be established.

Clinical implications and perspectives

Despite these limitations, the results underline the need for regular biochemical monitoring of diabetic and/or hypertensive hemodialysis patients. Particular attention should be paid to glycemic control, prevention of hyperkalemia, monitoring of calcium–phosphate parameters, correction of metabolic acidosis, and management of anemia.

In the Kinshasa context, prospective multicenter studies could complement these results by incorporating indicators of dialysis adequacy, notably Kt/V and urea reduction ratio, as well as nutritional parameters, iron status, and treatments received. Such data would also make it possible to study the relationship between biochemical abnormalities and clinical events, notably hospitalizations and mortality.

Summary of the discussion

Overall, the results of this study show that diabetic and/or hypertensive patients on hemodialysis at the Camp Lufungula Hemodialysis Center present a biochemical profile marked by accumulation of nitrogenous waste, fluid–electrolyte and calcium–phosphate disorders, metabolic acidosis, anemia, and marked inflammation. HTN is the dominant comorbidity, while the HTN/T2DM association is characterized by particularly marked disturbances of certain metabolic and acid–base parameters. These results are broadly consistent with available data on hemodialysis patients in sub-Saharan Africa and underline the importance of multidimensional biological monitoring adapted to the local context [14, 21, 24, 27, 30].

V. Conclusions

This retrospective, descriptive, and comparative study of diabetic and/or hypertensive patients on hemodialysis at the Camp Lufungula Hemodialysis Center in Kinshasa shows that ESRD is accompanied by numerous biological disturbances affecting several metabolic and physiological functions. The study population was characterized by a male predominance and a large representation of HTN, alone or combined with type 2 diabetes, underscoring the weight of these two chronic diseases in the occurrence and progression of CKD to the stage requiring hemodialysis.

Biochemically, the results showed marked retention of nitrogenous waste and disturbances of glucose metabolism, with more pronounced glycemic imbalance in diabetic patients, notably those with associated HTN. Fluid–electrolyte and calcium–phosphate disorders were frequent, involving sodium, potassium, calcium, and phosphorus. Acid–base balance was also notably disturbed, with lower

bicarbonate in patients with several metabolic risk factors, and the hematological and inflammatory profile was marked by significant anemia and elevated inflammatory markers. The coexistence of diabetes and HTN appears to be associated with more pronounced metabolic disturbances, which underlines the value of an integrated approach to the monitoring of these patients.

These findings highlight the need for regular, multidimensional biological monitoring adapted to the clinical context of hemodialysis patients and, as far as resources allow, covering renal function as well as glycemic, fluid–electrolyte, calcium–phosphate, acid–base, hematological, and inflammatory parameters. Such an approach would allow early detection of biological imbalances and help adapt clinical, nutritional, and dialytic management.

The retrospective, single-center design and the dependence on the quality and availability of information recorded in the medical files are the main limitations of this study. Prospective, multicenter, and longitudinal studies are needed to better characterize the evolution of biological abnormalities, to identify their determinants, and to study their relationship with complications and outcomes of hemodialysis patients in the DRC. This study nevertheless contributes to a better knowledge of the biological profile of diabetic and/or hypertensive hemodialysis patients in Kinshasa and provides local data useful for strengthening biological monitoring and promoting comprehensive, preventive, and individualized care for this particularly vulnerable population.

Abbreviations

ADA
American Diabetes Association
ANOVA
Analysis of variance
CKD
Chronic kidney disease
CKD-MBD
Chronic kidney disease–mineral and bone disorder
CRP
C-reactive protein
DRC
Democratic Republic of the Congo
EPO
Erythropoietin
ESC/ESH
European Society of Cardiology/European Society of Hypertension
ESRD
End-stage renal disease
GFR

Glomerular filtration rate

Hb

Hemoglobin

HbA1c

Glycated hemoglobin

HCO_3^-

Bicarbonate

HTN

Hypertension

KDIGO

Kidney Disease:Improving Global Outcomes

KDOQI

Kidney Disease Outcomes Quality Initiative

$PaCO_2$

Partial pressure of carbon dioxide

PaO_2

Partial pressure of oxygen

SD

Standard deviation

SPSS

Statistical Package for the Social Sciences

T2DM

Type 2 diabetes mellitus

WHO

World Health Organization

Declarations

Ethics approval and consent to participate

This study was approved by the Bioethics Committee of the Institut Supérieur des Techniques Médicales de Kinshasa under number 0241/CBE/ISTM/KIN/RDC/PMBBL/2024 of 22 December 2024. Given the retrospective, record-based nature of the study, individual patient consent was not required. Institutional authorization was obtained, and all data were anonymized before analysis.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Luzolo Kiniumba Raphael

interpretation of results and revision of scientific content.

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literature review and bibliographic revision.

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Author Contribution

Authors' contributionsTYT conceived the study, collected the data, performed the statistical analyses, interpreted the results, and drafted the manuscript. ZBB provided scientific supervision and critically revised the manuscript. IEJP contributed to methodological validation and scientific revision of the manuscript. LKR contributed to the interpretation of the results and revision of the scientific content. MNT conducted the literature review and revised the references. NAG contributed to the literature review and revision of the scientific content. MMF, an attending physician and records officer at the Camp Lufungula Police Hemodialysis Center, facilitated data collection.All authors read and approved the final version of the manuscript.

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Availability of data and materials

The datasets generated and analyzed during the current study are not publicly available due to strict institutional confidentiality agreements and security restrictions imposed by the Central Directorate of Health Services of the Congolese National Police (Police Nationale Congolaise, PNC). As the Camp Lufungula Hemodialysis Center is a specialized medical facility serving police personnel and high-ranking authorities, public sharing of the raw database is restricted to protect sensitive personal and health information. However, anonymized data extracts or summary tables are available from the corresponding author upon reasonable request and subject to prior institutional clearance from the Camp Lufungula authorities.

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Figures

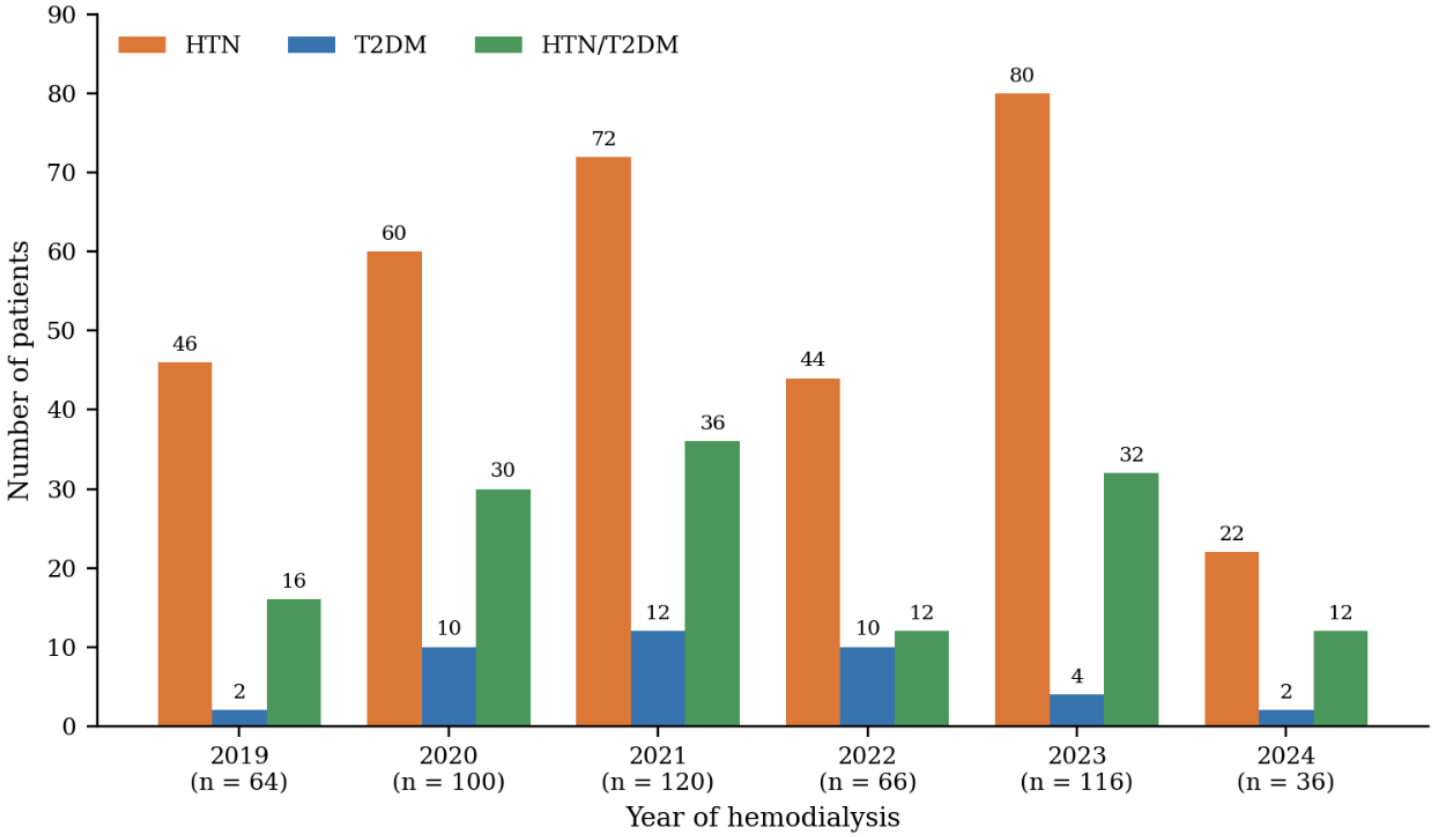

Figure 1

Number of patients by clinical category (HTN, T2DM, HTN/T2DM) and year of hemodialysis, 2019–2024. The number of patients per year is shown in parentheses. HTN, hypertension; T2DM, type 2 diabetes mellitus.