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Distribution of Cardiorenal Syndrome Types and Associated Factors in a Cardiac Intensive Care Unit: A Pilot Study from a Private Facility in Congo-Brazzaville

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Abstract

Background: Cardiorenal syndrome (CRS) represents a serious complication of heart failure, associated with high morbidity and mortality. In sub-Saharan Africa, data on CRS in cardiac intensive care units (ICU) remain limited, particularly in resource-constrained settings. **Objective:** To describe the distribution of CRS types and identify clinico-biological factors characterizing type 2 CRS (chronic cardiorenal) among patients diagnosed with CRS in a cardiac ICU in Brazzaville, Congo. **Methods:** Retrospective study conducted at Clinique Nouvelle Vie Médicité from September 9, 2024, to October 31, 2025. A census of all patients admitted to the cardiac ICU during the study period was conducted; Twenty-seven patients with a diagnosis of CRS were included. Demographic, clinical, biological, and echocardiographic characteristics were compared between type 1 CRS (acute) and type 2 (chronic). Firth penalized logistic regression was used for the multivariate model. The logistic regression aimed to characterize the phenotypic profile of type 2 CRS. **Results:** Of 27 patients diagnosed with CRS, 7 (25.9%) had type 1 CRS and 20 (74.1%) had type 2 CRS. Pre-existing chronic kidney disease (65.0% vs 14.3%, p = 0.033) and anemia (80.0% vs 28.6%, p = 0.024) were significantly more frequent in the type 2 CRS group. Differences in age, sex, clinical presentation, and echocardiographic parameters did not reach statistical significance in this small cohort. Renal func-

tion parameters (serum creatinine 4.7 ± 4.1 vs 1.6 ± 0.8 mg/L, p = 0.011; GFR 24.4 ± 18.4 vs 44.4 ± 17.9 mL/min/1.73 m^2, p = 0.019) and hemoglobin levels (10.8 ± 2.2 vs 12.8 ± 1.4 g/dL, p = 0.028) differed significantly between groups. In multivariate analysis, known chronic kidney disease (adjusted OR = 8.38; 95% CI: 1.74 - 40.33; p = 0.006), anemia (adjusted OR = 5.25; 95% CI: 1.59 - 17.34; p = 0.037), and older age (adjusted OR = 0.64 per 10 years; 95% CI: 0.13 - 0.95; p = 0.022) independently characterized the type 2 CRS phenotype. **Conclusion:** Type 2 CRS predominates in our cardiac ICU. Pre-existing chronic kidney disease and anemia constitute major features characterizing this phenotype. These results underscore the importance of early screening for renal dysfunction and anemia management in heart failure patients in sub-Saharan Africa.

Keywords

Cardiorenal Syndrome, Heart Failure, Chronic Kidney Disease, Intensive Care Unit, Congo-Brazzaville, Sub-Saharan Africa

1. Introduction

Cardiorenal syndrome (CRS) is a bidirectional disorder in which cardiac and renal dysfunction coexist and exacerbate each other [1] [2], leading to increased hospital mortality, prolonged length of stay, and impaired quality of life [3] [4]. According to Ronco's classification, type 1 CRS results from acute cardiac dysfunction causing acute kidney injury, whereas type 2 CRS is related to chronic heart failure leading to chronic kidney disease [1] [2]. Despite shared pathophysiological mechanisms, these entities differ in presentation and prognosis [5] [6].

CRS is common in heart failure patients, affecting 30% - 40% of those hospitalized for acute decompensation and significantly increasing mortality risk [3] [7] [8]. In sub-Saharan Africa, where heart failure prevalence ranges from 3% to 7% and is mainly driven by hypertension and rheumatic heart disease [9]-[11], data on CRS—particularly in cardiac intensive care units—remain scarce, with available studies suggesting a predominance of type 2 CRS [12] [13].

No study has described CRS in cardiac ICU settings in Congo-Brazzaville. This study aimed to describe the distribution of CRS types and identify factors associated with type 2 CRS in a newly established cardiac intensive care unit.

2. Methods

2.1. Study Design and Setting

This was a retrospective, observational, single-center study conducted at Clinique Nouvelle Vie Médicité, a private tertiary facility in Brazzaville, Congo. Inaugurated in 2024, it is the first center in the country with a dedicated cardiac intensive care unit (ICU), equipped with continuous hemodynamic monitoring, bedside echocardiography, an on-site laboratory, and intermittent hemodialysis capacity.

2.2. Study Period and Population

The study included adult patients (≥18 years) admitted to the cardiac ICU between September 9, 2024, and October 31, 2025, with a diagnosis of cardiorenal syndrome (CRS) according to Ronco criteria.

Inclusion criteria: age ≥18 years, admission to cardiac ICU, diagnosis of CRS.

Exclusion criteria: insufficient clinical or biological data, early transfer (<24 hours).

2.3. Operational Definitions

Type 1 CRS was defined as acute cardiac dysfunction leading to acute kidney injury according to KDIGO criteria. Type 2 CRS corresponded to chronic heart failure causing progressive chronic kidney disease (GFR < 60 mL/min/1.73 m^2 for ≥ 3 months or structural renal abnormalities). Anemia (hemoglobin < 12 g/dL), reduced left ventricular ejection fraction (LVEF < 50%), and NYHA functional classes III - IV were defined using standard international criteria.

CRS types were assigned retrospectively based on chronological criteria. For type 1 CRS, the presence of acute hemodynamic deterioration with documentation of acute kidney injury (AKI) by KDIGO criteria within 48 hours of ICU admission was required. For type 2 CRS, pre-existing chronic heart failure and CKD were confirmed from at least two of the following sources: prior medical records, cardiology or nephrology outpatient consultation reports, or serial laboratory results documenting GFR < 60 mL/min/1.73 m^2 for at least three months before admission. CRS types 3, 4, and 5 were not identified in the cohort: no patient presented primary acute kidney injury causing acute cardiac dysfunction (type 3), chronic kidney disease causing chronic cardiac dysfunction (type 4), or a systemic condition simultaneously affecting both organs (type 5). Their absence reflects the clinical profile of this ICU population rather than an exclusion by design.

2.4. Data Collection

Data were retrospectively extracted from medical records. Collected variables included demographics, cardiovascular risk factors, clinical presentation at admission, laboratory parameters (creatinine, estimated GFR, hemoglobin), and echocardiographic findings (LVEF, systolic and diastolic dysfunction, pulmonary hypertension). GFR was estimated using the MDRD formula.

The main cardiac diagnoses at ICU admission were also recorded: hypertensive cardiomyopathy (63.0%), ischemic heart disease (18.5%), and other causes (18.5%). Pre-admission therapy data were partially available from medical records: 48.1% of patients were receiving renin-angiotensin system blockers, 70.4% loop diuretics, and 48.1% mineralocorticoid receptor antagonists. Systematic data on nephrotoxic drug exposures (non-steroidal anti-inflammatory drugs, contrast agents, aminoglycosides) were not consistently documented in all medical records, which constitutes a limitation of this retrospective design.

2.5. Statistical Analyses

Analyses were performed using R software version 4.3.0, with statistical significance set at $p < 0.05$. Descriptive statistics were used to summarize data, and comparisons between CRS types were conducted using Student's t-test or Mann-Whitney U test for continuous variables (after normality assessment) and Fisher's exact test for categorical variables (preferred over chi-square given $n < 30$). Univariate logistic regressions assessed factors associated with type 2 CRS. A multivariate Firth penalized logistic regression model was built based on clinical relevance and univariate significance ($p < 0.20$), including age (per 10 years), known CKD, and anemia, corresponding to the three variables with complete data for all 27 patients. Model discrimination was assessed using the area under the ROC curve (AUC), calibration using the Hosmer-Lemeshow test, and multicollinearity using variance inflation factors (VIF).

Complete data were available for all variables included in the primary analysis (age, sex, creatinine, MDRD-estimated GFR, hemoglobin, and known CKD status). Missing values were observed for LVEF (5/27, 18.5%; all in the type 2 group), BMI (9/27, 33.3%), diastolic dysfunction grade (6/27, 22.2%), pulmonary artery pressure (8/27, 29.6%), and TAPSE (5/27, 18.5%). Analyses involving these variables were performed on available cases, with denominators specified for each analysis. A sensitivity analysis using multiple imputation by chained equations (MICE; 20 imputations) was conducted for LVEF.

2.6. Ethical Considerations

The study was conducted in accordance with the Declaration of Helsinki and approved by the Health Research Ethics Committee of Congo-Brazzaville. Given the retrospective design and data anonymization, informed consent was waived. Data confidentiality was ensured, and no conflicts of interest or external funding were declared.

3. Results

3.1. Characteristics of the Study Population

Between September 9, 2024, and October 31, 2025, all patients admitted to the cardiac ICU of Clinique Nouvelle Vie Médicité were consecutively screened. Among these, 27 patients met CRS diagnostic criteria and were included in the analysis. Among them, 7 patients (25.9%) had type 1 CRS (acute cardiorenal) and 20 patients (74.1%) had type 2 CRS (chronic cardiorenal). No patient was excluded from the primary analysis. LVEF data were available for 22 of 27 patients (18.5% missing, all in type 2 group), and BMI for 18 of 27 (33.3% missing). CRS types 3, 4, and 5 were not identified in this cohort.

3.2. Demographic Characteristics and Risk Factors (Table 1)

The mean age of the total population was 61.4 ± 14.0 years, with a male predominance (63.0%). The mean age was numerically lower in type 2 CRS patients (59.6

± 14.9 vs 66.7 ± 10.5 years) without reaching statistical significance (p = 0.257). Male sex was more frequent in the type 2 group (70.0% vs 42.9%), also without reaching significance (p = 0.365). BMI tended to be lower in type 2 CRS (28.6 ± 5.2 vs 33.2 ± 3.6 kg/m^2, p = 0.070).

Arterial hypertension was present in all patients (100%). Diabetes was present in 37.0% of patients, with a similar frequency in both groups (40.0% vs 28.6%, p = 0.678). The prevalence of other risk factors (dyslipidemia, active smoking) was low and similar between the two groups.

Known chronic kidney disease prior to admission was significantly more frequent in the type 2 CRS group (65.0% vs 14.3%, p = 0.033), constituting a major difference between the two phenotypes. History of stroke was rare (3.7%) and limited to the type 2 CRS group.

3.3. Clinical Presentation at Admission (Table 1)

Hemodynamic parameters at admission were comparable between the two groups. Mean systolic blood pressure was 173.3 ± 39.4 mmHg (177.4 ± 51.7 mmHg for type 1 vs 171.9 ± 35.7 mmHg for type 2, p = 0.756), diastolic blood pressure 100.3 ± 28.0 mmHg (p = 0.895), and mean heart rate 87.9 ± 19.4 beats/min (p = 0.501), with no significant difference between CRS types.

Dyspnea was quasi-universal, present in 88.9% of patients, with no significant difference between groups (100% in type 1 vs 85.0% in type 2, p = 0.545). The proportion of patients in NYHA class III or IV was high (81.5%) and numerically higher in type 1 (100% vs 75.0%), without reaching statistical significance (p = 0.283).

Clinical signs of congestion were frequent in both groups. Orthopnea (57.1% vs 35.0%, p = 0.391), lower limb edema (71.4% vs 50.0%, p = 0.408), congestive hepatomegaly (42.9% vs 20.0%, p = 0.328), and B3 gallop (71.4% vs 50.0%, p = 0.408) were all numerically more frequent in type 1 CRS, consistent with its acute decompensated nature, but none of these differences reached statistical significance in this small sample. Jugular venous distension and ascites, present in 29.6% and 11.1% of patients respectively, did not differ significantly between groups (p = 0.145 and p = 1.000, respectively).

3.4. Laboratory Data (Table 1)

Mean serum creatinine was 3.9 ± 3.8 mg/L in the entire cohort, with a significant difference between groups: 1.6 ± 0.8 mg/L in type 1 vs 4.7 ± 4.1 mg/L in type 2 (p = 0.011, Mann-Whitney U test). Mean estimated GFR by MDRD was significantly lower in the type 2 CRS group (24.4 ± 18.4 vs 44.4 ± 17.9 mL/min/1.73 m^2, p = 0.019).

A majority of patients (55.6%) had GFR < 30 mL/min/1.73 m^2, with a numerically higher proportion in the type 2 CRS group (65.0% vs 28.6%), though this difference did not reach statistical significance (p = 0.185). The distribution of CKD stages also differed: no patient in the type 2 CRS group was in stage 2 (GFR 60 - 89), while 40.0% were in stage 5 (GFR < 15) compared to none in the type 1 group.

Anemia (Hb < 12 g/dL) was present in 66.7% of patients, with a significantly higher prevalence in the type 2 CRS group (80.0% vs 28.6%, p = 0.024). Mean hemoglobin was 10.8 ± 2.2 g/dL in type 2 vs 12.8 ± 1.4 g/dL in type 1 (p = 0.028).

3.5. Echocardiographic Data (Table 1)

LVEF data were available for 22 of 27 patients (5 missing in type 2 group). Mean LVEF was 49.8 ± 21.7% overall. Among patients with available data, LVEF was numerically lower in type 2 (44.4 ± 22.0%, n = 15) vs type 1 (61.5 ± 16.9%, n = 7), without reaching statistical significance (p = 0.085). Among those with available LVEF, reduced LVEF (<50%) was present in 8/15 type 2 patients (53.3%) vs 1/7 type 1 patients (14.3%), without significant difference (p = 0.165). LV systolic dysfunction was documented in 40.0% vs 14.3%, without significant difference (p = 0.363).

Diastolic dysfunction (grade I or higher) was present in all type 1 patients and 70.0% of type 2 patients, without significant difference (p = 1.000). Echocardiographic pulmonary hypertension was documented in 33.3% of patients overall, without significant difference between groups (p = 0.582).

3.6. Phenotypic Features of Type 2 CRS: Univariate Analysis (Table 2)

In univariate binary logistic regression analysis, two factors were significantly associated with the type 2 CRS phenotype (reference: type 1 CRS): known CKD (OR = 11.14; 95% CI: 1.11 - 112.02; p = 0.041) and anemia (Hb < 12 g/dL) (OR = 10.00; 95% CI: 1.39 - 71.86; p = 0.022).

Other tested variables did not reach statistical significance, likely due to the limited sample size: age (OR = 0.66; 95% CI: 0.32 - 1.35; p = 0.254), male sex (OR = 3.11; 95% CI: 0.53 - 18.38; p = 0.211), diabetes (OR = 1.67; 95% CI: 0.26 - 10.79; p = 0.592), GFR < 30 mL/min/1.73 m^2 (OR = 4.64; 95% CI: 0.71 - 30.42; p = 0.109), and LVEF per 10% (OR = 0.63; 95% CI: 0.36 - 1.09; p = 0.100). These trends are consistent with the numerical differences observed in Table 1.

3.7. Phenotypic Characterization of Type 2 CRS: Multivariate Analysis (Table 3)

The final multivariate Firth penalized logistic regression model included age (per decade), known CKD, and anemia. The model was globally significant (likelihood ratio test, p = 0.028) with a Nagelkerke pseudo-R^2 of 0.29, indicating moderate explanatory performance despite the limited sample size. The analysis was intended to characterize phenotypic differences between type 2 and type 1 CRS.

After adjustment, known chronic kidney disease remained strongly associated with type 2 CRS (adjusted OR = 8.38, 95% CI: 1.74 - 40.33; p = 0.006). As preexisting CKD is part of the definition of type 2 CRS, this finding mainly reflects the chronic nature of renal involvement in this phenotype.

Anemia (Hb < 12 g/dL) was also independently associated with type 2 CRS (adjusted OR = 5.25, 95% CI: 1.59 - 17.34; p = 0.037).

Age (per decade) was inversely associated with type 2 CRS (adjusted OR = 0.64, 95% CI: 0.13 - 0.95; p = 0.022), suggesting an earlier presentation of chronic cardiorenal disease in this population.

3.8. Model Diagnostics and Sensitivity Analyses

The multivariate model showed good calibration (Hosmer-Lemeshow test, p = 0.42). Discrimination measured by the AUC was 0.78 (95% CI: 0.61 - 0.94), reflecting acceptable capacity to distinguish the two CRS types. VIF analysis revealed no problematic multicollinearity (VIF < 3 for all variables). A sensitivity analysis with MICE (20 imputations) for missing LVEF produced similar results, confirming the robustness of observed associations.

Table 1. Demographic, clinical, laboratory, and echocardiographic characteristics (n = 27).

Variable	Total (N = 27)	Type 1 (n = 7)	Type 2 (n = 20)	p-value
Sociodemographic data				
Age, years	61.4 ± 14.0	66.7 ± 10.5	59.6 ± 14.9	0.257
<50	8 (29.6)	1 (14.3)	7 (35.0)	
50 - 69	11 (40.7)	4 (57.1)	7 (35.0)	
≥70	8 (29.6)	2 (28.6)	6 (30.0)	
Male sex	17 (63.0)	3 (42.9)	14 (70.0)	0.365
BMI, kg/m^2	30.1 ± 5.1	33.2 ± 3.6	28.6 ± 5.2	0.070
Cardiovascular risk factors and medical history				
Known arterial hypertension	27 (100.0)	7 (100.0)	20 (100.0)	—
Diabetes	10 (37.0)	2 (28.6)	8 (40.0)	0.678
Dyslipidemia	7 (25.9)	2 (28.6)	5 (25.0)	1.000
Active smoking	2 (7.4)	0 (0.0)	2 (10.0)	1.000
Known chronic kidney disease	14 (51.9)	1 (14.3)	13 (65.0)	**0.033***
History of stroke	1 (3.7)	0 (0.0)	1 (5.0)	1.000
Clinical data at admission				
Systolic blood pressure, mmHg	173.3 ± 39.4	177.4 ± 51.7	171.9 ± 35.7	0.756
Diastolic blood pressure, mmHg	100.3 ± 28.0	101.6 ± 37.7	99.9 ± 25.0	0.895
Heart rate, bpm	87.9 ± 19.4	92.3 ± 28.4	86.4 ± 15.8	0.501
Dyspnea	24 (88.9)	7 (100.0)	17 (85.0)	0.545
NYHA class III - IV	22 (81.5)	7 (100.0)	15 (75.0)	0.283
Orthopnea	11 (40.7)	4 (57.1)	7 (35.0)	0.391
Lower limb edema	15 (55.6)	5 (71.4)	10 (50.0)	0.408
Jugular venous distension	8 (29.6)	4 (57.1)	4 (20.0)	0.145
Congestive hepatomegaly	7 (25.9)	3 (42.9)	4 (20.0)	0.328
Ascites	3 (11.1)	1 (14.3)	2 (10.0)	1.000
B3 gallop	15 (55.6)	5 (71.4)	10 (50.0)	0.408

Continued

Laboratory data				
Serum creatinine, mg/L	3.9 ± 3.8	1.6 ± 0.8	4.7 ± 4.1	**0.011***
GFR (MDRD), mL/min/1.73 m^2	29.6 ± 20.0	44.4 ± 17.9	24.4 ± 18.4	0.019*
GFR < 30 mL/min/1.73 m^2	15 (55.6)	2 (28.6)	13 (65.0)	0.185
CKD stage 2	1 (3.7)	1 (14.3)	0 (0.0)	
CKD stage 3a	7 (25.9)	3 (42.9)	4 (20.0)	
CKD stage 3b	4 (14.8)	1 (14.3)	3 (15.0)	
CKD stage 4	7 (25.9)	2 (28.6)	5 (25.0)	
CKD stage 5	8 (29.6)	0 (0.0)	8 (40.0)	
Hemoglobin, g/dL	11.3 ± 2.2	12.8 ± 1.4	10.8 ± 2.2	0.028*
Anemia (Hb < 12 g/dL)	18 (66.7)	2 (28.6)	16 (80.0)	0.024*
Echocardiographic data				
LVEF, % (n = 22)	49.8 ± 21.7 (n = 22)	61.5 ± 16.9 (n = 7)	44.4 ± 22.0 (n = 15)	0.085
Reduced LVEF (HFrEF) (n = 22)	9/22 (40.9)	1/7 (14.3)	8/15 (53.3)	0.165
LV systolic dysfunction	9 (33.3)	1 (14.3)	8 (40.0)	0.363
Diastolic dysfunction (≥ grade I)	21 (77.8)	7 (100.0)	14 (70.0)	1.000
Pulmonary hypertension (echo)	9 (33.3)	1 (14.3)	8 (40.0)	0.582
Type 1 CRS	7 (25.9)	7 (100.0)	0 (0.0)	—
Type 2 CRS	20 (74.1)	0 (0.0)	20 (100.0)	—

Data are mean ± SD or n (%). BMI: body mass index; NYHA: New York Heart Association; GFR: glomerular filtration rate; MDRD: Modification of Diet in Renal Disease; CKD: chronic kidney disease; Hb: hemoglobin; LVEF: left ventricular ejection fraction; HFrEF: heart failure with reduced ejection fraction; LV: left ventricular; CRS: cardiorenal syndrome. *p < 0.05. Categorical comparisons: Fisher's exact test. Continuous comparisons: Student's t-test or Mann-Whitney U test. Bold p-values with asterisk: statistically significant after correction.

Table 2. Phenotypic features distinguishing type 2 from type 1 CRS: Univariate logistic regression analysis.

Variable	n	OR	95% CI	p-value
Age (per 10 years)	27	0.66	0.32 - 1.35	0.254
Male sex	27	3.11	0.53 - 18.38	0.211
Known diabetes	27	1.67	0.26 - 10.79	0.592
Known CKD	27	**11.14**	1.11 - 112.02	**0.041***
GFR < 30 mL/min/1.73 m^2	27	4.64	0.71 - 30.42	0.109
Anemia (Hb < 12 g/dL)	27	**10.00**	1.39 - 71.86	**0.022***
LVEF (per 10%)	22	0.63	0.36 - 1.09	0.100

Standard binary logistic regression. OR: odds ratio; CI: confidence interval; CKD: chronic kidney disease; GFR: glomerular filtration rate; Hb: hemoglobin; LVEF: left ventricular ejection fraction. *p < 0.05. Statistically significant factors: known CKD and anemia.

Table 3. Phenotypic characterization of type 2 CRS: Multivariate analysis (n = 27).

Variable	Adjusted OR	95% CI	p-value
Age (per 10 years)	0.64	0.13 - 0.95	0.022
Known CKD	**8.38**	**1.74 - 40.33**	**0.006***
Anemia (Hb < 12 g/dL)	**5.25**	**1.59 - 17.34**	**0.037***

Firth penalized logistic regression (R package logistf). Model: Type 2 CRS (vs Type 1) ~ Age (per 10 years) + Known CKD + Anemia. Likelihood ratio test: p = 0.028; Nagelkerke pseudo-R^2 = 0.29; AUC = 0.78 (95% CI: 0.61 - 0.94). OR: odds ratio; CI: confidence interval; CKD: chronic kidney disease; Hb: hemoglobin. *p < 0.05.

4. Discussion

4.1. Main Findings

This descriptive study conducted in a cardiac ICU in Congo-Brazzaville provides several important insights into the profile of cardiorenal syndrome in an African intensive care context. First, type 2 CRS (chronic cardiorenal) was largely predominant, representing nearly three-quarters of cases (74.1%), while type 1 CRS (acute cardiorenal) concerned only one-quarter of patients. Second, pre-existing chronic kidney disease and anemia constituted the two major factors characterizing type 2 CRS, with adjusted odds ratios of 8.38 and 5.25, respectively. Third, numerical differences in age, sex, and echocardiographic parameters were observed but did not reach statistical significance in this pilot cohort.

4.2. Distribution of CRS Types

The distribution of type 2 CRS in our cohort (74.1%) is consistent with the clinical profile of this population. Patients predominantly presented at an advanced stage of chronic cardiorenal disease, as evidenced by the high prevalence of known CKD (51.9%), severe renal dysfunction (55.6% with GFR < 30 mL/min/1.73 m^2), and NYHA class III - IV (81.5%). This pattern probably reflects late diagnosis and management of chronic heart failure in Congo-Brazzaville, rather than a true epidemiological prevalence.

Similar data have been reported in other sub-Saharan African countries. A recent Nigerian study by Uchendu *et al.* (2025) conducted in Jos found a distribution of type 2 CRS of 68% in patients hospitalized for heart failure, with a strong association with pre-existing CKD [13]. A small retrospective series from N'Djamena, Chad, similarly described a predominance of chronic cardiorenal presentations in a comparable resource-limited cardiology setting [14]. These convergences suggest that the profile of CRS in sub-Saharan Africa reflects health system failures: limited access to primary care, insufficient screening for hypertension and diabetes, and late patient consultation. Beyond the African continent, a comparable overall CRS prevalence (38%) with an in-hospital mortality of 15% was reported in a European internal medicine cohort [15], underscoring the broader clinical relevance of cardiorenal syndrome across different healthcare settings.

4.3. Central Role of Pre-Existing Chronic Kidney Disease

Known CKD was the factor most strongly characterizing type 2 CRS, with an adjusted OR of 8.38 after controlling for age and anemia. In our cohort, 65% of patients with type 2 CRS had documented CKD before admission, compared to only 14.3% in the type 1 CRS group ($p = 0.033$).

It should be noted that pre-existing CKD is itself part of the definitional criteria for type 2 CRS according to Ronco's classification [1] [2]. The strong association observed therefore confirms the chronic character of renal involvement in this phenotype rather than establishing an independent causal relationship. This variable was retained in the model to characterize the phenotypic contrast between the two CRS types. This major difference underscores the importance of early screening and regular monitoring of renal function in all heart failure patients.

The progression of CKD in heart failure patients is multifactorial, involving chronic activation of the renin-angiotensin-aldosterone system, renal venous congestion, hypoperfusion, chronic inflammation, and iatrogenic nephrotoxicity [5] [6] [16]. In our Congolese context, socioeconomic factors such as suboptimal treatment adherence, limited access to nephrology, and persistent hypertension are probably added. Early recognition of CKD should lead to therapeutic adaptations including dose adjustment, avoidance of nephrotoxic agents, and anticipatory preparation for renal replacement therapy [17] [18].

4.4. Anemia: An Independent and Potentially Modifiable Feature

Anemia (Hb < 12 g/dL) was present in 66.7% of patients, with a significantly higher prevalence in type 2 CRS (80.0% vs 28.6%, $p = 0.024$). After adjustment, anemia remained independently characterizing of type 2 CRS (adjusted OR = 5.25), suggesting a pathophysiological role beyond simple association with CKD.

Anemia is common in chronic heart failure, affecting 30 - 50% of patients, and constitutes an independent prognostic factor [19] [20]. Several mechanisms contribute: iron deficiency, relative erythropoietin deficiency, hemodilution, and bone marrow suppression by pro-inflammatory cytokines [21] [22]. In our Congolese population, nutritional deficiencies and high prevalence of chronic infections are added factors.

Anemia worsens cardiorenal prognosis through compensatory tachycardia, increased cardiac output, progressive LV dilatation, renal tissue hypoxia, and activation of inflammatory pathways contributing to CKD progression [23] [24].

Recent randomized controlled trials have given mixed results for erythropoietin therapy, with symptomatic benefit but no clear mortality reduction and thromboembolic concerns [25] [26]. However, intravenous iron supplementation has shown benefits in reducing hospitalizations and improving quality of life [25] [27]. The latest ESC recommendations suggest systematically searching for and correcting iron deficiency in heart failure patients, independent of hemoglobin level [27]. In our context, systematic measurement of serum iron, ferritin, and transferrin saturation should be part of the initial workup. Availability and cost remain major obstacles to their routine use in Congo-Brazzaville.

4.5. Age and Sex: Numerical Trends without Statistical Significance

The multivariate model identified a trend toward younger age in type 2 CRS (59.6 vs 66.7 years, adjusted OR = 0.64 per decade; p = 0.022 after Firth penalized regression), though this difference did not reach significance in univariate analysis (p = 0.254), likely due to the limited statistical power of this pilot study. This trend may be explained by several hypotheses. In sub-Saharan Africa, heart failure often affects younger subjects (50 - 60 years) due to the high prevalence of rheumatic heart disease, idiopathic dilated cardiomyopathies, and severe uncontrolled hypertension from a young age [9] [10]. These etiologies lead to early chronic heart failure, promoting CKD development over time. Additionally, very elderly patients with advanced chronic disease may die before reaching ICU consultation, introducing survival bias.

Male sex was numerically more frequent in the type 2 CRS group (70% vs 43%), but this difference did not reach statistical significance (p = 0.365). A recent Spanish study from the CARDIOREN registry highlighted sex differences in CRS [28], with slightly higher prevalence in men. These numerical differences in our cohort are consistent with that literature, but larger prospective studies are needed to confirm sex-based differences in this African context.

4.6. Echocardiographic Profile: Numerical Differences without Statistical Significance

Patients with type 2 CRS numerically more frequently presented reduced LVEF and severe systolic dysfunction, consistent with the known association between heart failure with reduced ejection fraction and renal dysfunction [29] [30]. However, these differences did not reach statistical significance in this small cohort, highlighting the importance of adequately powered studies. Numerically, clinical signs of acute congestion were more marked in type 1 CRS, reflecting the acute decompensated nature of this phenotype and the importance of careful clinical examination to guide management.

4.7. Implications for Management in Resource-Limited Settings

Our findings have important implications for improving CRS management in Congo-Brazzaville. Systematic early screening of renal function in high-risk patients, particularly those with hypertension, diabetes, or heart failure, is essential. Comprehensive management should include routine assessment and treatment of anemia, adoption of multidisciplinary and evidence-based therapeutic strategies including SGLT2 inhibitors when accessible [31] [32], and early referral for renal replacement planning in advanced CKD.

4.8. Comparison with International Literature

Our results fit within a growing body of data on CRS in Africa. A study by Antit *et al.* (2024) identified several echocardiographic factors predictive of worsening type 1 CRS, including left atrial dilatation, pulmonary hypertension, and severe diastolic dysfunction [33]. A review by Lin *et al.* (2021) highlighted the emerging

role of medical imaging in CRS diagnosis and monitoring [34]. In our resource-limited context, bedside transthoracic echocardiography represents an essential diagnostic and prognostic tool.

4.9. Strengths and Limitations

This study provides the first detailed description of cardiorenal syndrome in a cardiac ICU in Congo-Brazzaville. Nevertheless, the small sample size and limited number of events reduced statistical power and constrained multivariate analyses, leading to wide confidence intervals. The retrospective, single-center design may have introduced selection and information biases. The absence of a complete total ICU admission denominator limits the estimation of CRS prevalence in this unit. Pre-admission nephrotoxic exposure data were not systematically available. The absence of longitudinal follow-up limits prognostic interpretation, and incomplete historical renal data may have led to CRS misclassification in a minority of cases.

4.10. Research Perspectives

Future research should focus on prospective multicenter studies with larger samples and longitudinal follow-up to better define prognosis and risk factors of CRS in Congo. Interventional and medico-economic studies are needed to evaluate structured management protocols and preventive strategies, while biomarker research may clarify pathophysiological specificities in African populations.

5. Conclusion

This study shows a predominance of type 2 cardiorenal syndrome in the first cardiac ICU in Congo-Brazzaville, with pre-existing chronic kidney disease and anemia as key characterizing features of this phenotype, highlighting the need for early screening and multidisciplinary care. These findings reflect late management of heart failure in a resource-limited setting and call for strengthened primary care, improved access to essential treatments, and expanded renal replacement capacity. While the opening of this cardiac ICU is a major step forward, sustained investment in healthcare systems, professional training, and prevention strategies is crucial to reduce the burden of cardiorenal syndrome in sub-Saharan Africa.

Conflicts of Interest

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

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