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Original

Clinical Outcomes of Cardiorenal Syndrome in Heart Failure Patients: A Six-Month Observational Follow-Up

[1]Malunjkar Nikil Shankar, [2]*Dr. Arundhati Barua, [3]Dr. Smita Patil, [4]Dr. Anurag Rawat, [5]Dr. Kunal Gururani, [6]Dr. Chandra Mohan Belwal

[1]D Y Patil School of Medicine & Hospital Nerul Navi Mumbai, [2]Professor, D Y Patil School of Medicine & Hospital Nerul Navi Mumbai, [3]Professor and Head of department of general medicine, D Y Patil School of Medicine & Hospital Nerul Navi Mumbai, [4]Professor and Head in Department of Cardiology, Swami Rama Himalayan University, Himalayan Hospital Joly Grant, Doiwala, Sangatiya Walakhur, Uttarakhand 248016, [5]Associate Professor in Department of Cardiology, Swami Rama Himalayan University, Himalayan Hospital Joly Grant, Doiwala, Sangatiya Walakhur, [6]Associate Professor in Department of Cardiology, Swami Rama Himalayan University, Himalayan Hospital Joly Grant, Doiwala, Sangatiya Walakhur

*Corresponding Email- manoj.adhav1111@gmail.com
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ABSTRACT

Background: Cardiorenal Syndrome (CRS) represents a bidirectional interplay between cardiac and renal dysfunction, where impairment of one organ precipitates or exacerbates dysfunction in the other. It is commonly encountered in heart failure (HF) patients and is associated with poor prognosis. Despite increasing awareness, data on the clinical outcomes and prognostic predictors of CRS in Indian populations remain limited.

Objective: To evaluate the prevalence, risk factors, and six-month clinical outcomes of CRS in patients with heart failure admitted to a tertiary care hospital, and to identify predictors of mortality

Methods: This prospective observational study included 70 patients with heart failure (≥12 years) admitted to D. Y. Patil Hospital, Navi Mumbai (2023–2024). Patients were classified into CRS and non-CRS groups based on consensus diagnostic criteria. Demographic, clinical, biochemical, and echocardiographic parameters were recorded. Patients were followed for six months to assess survival and rehospitalization. Statistical analyses were performed using SPSS version 26.0, with logistic regression to identify independent mortality predictors.

Results: Among 70 HF patients, 48 (68.5%) had CRS. The mean age was 60.53 ± 15.55 years, with a male predominance (62.5%). The most common comorbidities were hypertension (63.9%) and diabetes mellitus (50%). Type I CRS was the most frequent subtype (54.1%). Six-month mortality was significantly higher in CRS patients (29.2%) compared to non-CRS patients (0%) ($p < 0.01$). Logistic regression analysis identified elevated NT-proBNP (>2000 pg/mL) (OR 3.8, p=0.008), reduced LVEF (<40%) (OR 2.9, p=0.032), serum creatinine >2 mg/dL (OR 2.5, p=0.046), and eGFR <45 mL/min/1.73m² (OR 3.2, p=0.018) as independent predictors of mortality. Kaplan–Meier analysis showed significantly lower survival probability among CRS patients ($p < 0.01$).

Conclusion: CRS was highly prevalent among heart failure patients and strongly associated with increased mortality and poor outcomes. Reduced ejection fraction, elevated NT-proBNP, and renal dysfunction were key predictors of death. Early detection, vigilant monitoring of renal and cardiac function, and timely interventions are vital to improving prognosis in this high-risk group.

Keywords: Cardiorenal syndrome, Heart failure, NT-proBNP, eGFR, Mortality, Prognosis

1. INTRODUCTION

Cardiorenal syndrome (CRS) represents a complex pathophysiological interplay between the heart and kidneys, where dysfunction in one organ can precipitate or exacerbate dysfunction in the other. This bidirectional relationship significantly complicates the management of heart failure (HF) patients and is associated with increased morbidity and mortality. CRS has been classified into five distinct types based on the primary organ insult and the temporal sequence of cardiac and renal dysfunction (1). Type I CRS is characterized by acute heart failure leading to acute kidney injury, whereas Type II involves chronic heart failure causing progressive chronic kidney disease. Conversely, Type III arises from acute kidney injury causing acute cardiac dysfunction, and Type IV results from chronic kidney disease precipitating chronic cardiac dysfunction. Type V encompasses systemic conditions, such as sepsis or systemic lupus erythematosus, that simultaneously impair both cardiac and renal function. This classification underscores the heterogeneity of CRS and its variable clinical manifestations, complicating diagnosis, prognosis, and therapeutic approaches (2).

The pathophysiology of CRS is multifactorial and not fully understood. Hemodynamic factors, such as reduced cardiac output and venous congestion, neurohormonal activation including the renin-angiotensin-aldosterone system (RAAS), sympathetic overactivity, and inflammatory mediators, all contribute to renal impairment in HF. Similarly, renal dysfunction can exacerbate cardiac injury through fluid overload, electrolyte disturbances, and uremic toxicity. In clinical practice, CRS is often associated with worsening renal function, diuretic resistance, and advanced cardiac remodeling. These mechanisms collectively result in poor clinical outcomes, including higher hospitalization rates, progression to chronic kidney disease (CKD), and elevated mortality (3).

Heart failure is a leading cause of hospitalization worldwide, with prevalence increasing substantially with age. Epidemiological studies, such as the Atherosclerosis Risk in Communities (ARIC) study, have demonstrated that HF incidence is significantly higher in individuals with impaired renal function, with an estimated threefold increase in patients with an eGFR <60 mL/min/1.73 m² compared to those with normal renal function. Conversely, renal dysfunction is a powerful predictor of adverse outcomes in HF patients, whether on dialysis or not. The coexistence of HF and renal impairment, as seen in CRS, thus represents a high-risk phenotype with complex management needs and poor prognosis (4).

Despite growing recognition of CRS as a distinct clinical entity, several gaps remain in understanding its prevalence, risk factors, and prognostic implications, particularly in the Indian context. While global studies have elucidated the associations between advanced age, comorbidities such as diabetes mellitus, hypertension, ischemic heart disease, and adverse outcomes in CRS, local epidemiological data remain limited. Furthermore, most studies have focused on individual aspects of CRS, such as acute kidney injury in acute decompensated HF, with limited longitudinal follow-up examining six-month outcomes including mortality, rehospitalization, and renal progression. Understanding these outcomes is crucial for tailoring management strategies, optimizing interventions, and identifying patients at highest risk for poor prognosis (5).

The prognostic significance of CRS in HF is well established. Patients with concomitant renal dysfunction exhibit higher rates of hospitalization, progression to end-stage renal disease, and mortality. Additionally, therapeutic interventions such as percutaneous coronary intervention (PCI), coronary artery bypass grafting (CABG), or medical management may differentially impact outcomes in this population, depending on the severity of cardiac and renal impairment. Despite this, evidence remains scarce regarding the real-world outcomes of CRS patients in tertiary care centers, highlighting the need for observational studies with detailed clinical, biochemical, and echocardiographic assessment (6).

Given these considerations, the present study was designed to assess the prevalence, risk factors, and six-month clinical outcomes of CRS in HF patients admitted to a tertiary care hospital in Navi Mumbai. By evaluating demographic factors, comorbidities, clinical and biochemical parameters, and therapeutic interventions, this study aims to fill the existing knowledge gap and provide insights into prognostic determinants of CRS. Understanding these factors is critical for early identification of high-risk patients, optimizing treatment strategies, and ultimately improving morbidity and mortality outcomes in this vulnerable population (7).

2. MATERIALS AND METHODS

This observational study was conducted at D. Y. Patil Hospital, Nerul, Navi Mumbai, over a period of one year (2023–2024) and included patients

aged ≥12 years admitted with a diagnosis of heart failure, with or without cardiorenal syndrome (CRS), who provided informed consent.

Patients with congenital heart disease, structural cardiac anomalies, or pre-existing chronic kidney disease with renal artery stenosis were excluded. A total of 70 patients were enrolled, calculated using the formula for sample size estimation ($n = Z^2 \times p \times q / E^2$) with a 95% confidence level, 10% absolute error, and an expected CRS prevalence of 24%. Heart failure diagnosis was confirmed based on clinical evaluation, biochemical parameters, and echocardiographic assessment following American Heart Association (AHA) guidelines. CRS was defined and classified into Types I–V based on the current consensus criteria.

Baseline demographic data, medical history, comorbidities (including diabetes mellitus, hypertension, ischemic heart disease, and chronic kidney disease), lifestyle habits (smoking, alcohol, and tobacco use), and current medications were recorded using a structured proforma. Clinical examination included measurement of vital signs, body mass index, waist circumference, assessment of jugular venous pressure, presence of pedal edema, and pallor. Laboratory investigations comprised complete blood count, renal function tests (blood urea nitrogen, serum creatinine, eGFR), electrolytes, urinary sodium, potassium, and chloride levels, lipid profile, and NT-proBNP to assess cardiac stress. Imaging studies included ultrasonography of kidneys to assess cortical echogenicity, kidney size, and corticomedullary differentiation. Echocardiography was performed to classify left ventricular ejection fraction (LVEF) into HFrEF (<40%), HFmrEF (40–49%), and HFpEF (≥50%).

All patients received standard-of-care treatment for heart failure and CRS as clinically indicated, including medical management, percutaneous coronary intervention (PCI), coronary artery bypass grafting (CABG), or thrombolysis, with interventions documented in detail. Patients were followed prospectively for six months to capture primary outcomes, including survival status and hospital readmissions due to heart failure exacerbation or CRS-related complications. Rehospitalization was defined as admission to any hospital for acute decompensation, volume overload, or worsening renal function within the follow-up period. Data were recorded on a structured case report form and analyzed using SPSS Version 26.0, with continuous variables expressed as mean ± standard deviation and categorical variables as frequency and percentage.

Comparative analysis between survivors and non-survivors, as well as rehospitalized versus non-rehospitalized patients, was performed using unpaired t-tests or Mann–Whitney U tests for continuous variables and Chi-square or Fisher's exact tests for categorical variables. Multivariate logistic regression was conducted to identify independent predictors of mortality and rehospitalization, with a p-value <0.05 considered statistically significant. Graphical representation of data was done using Microsoft Excel 2021. Ethical approval was obtained from the institutional ethics committee, and all procedures adhered to the Declaration of Helsinki principles, ensuring patient confidentiality and voluntary participation.

3. RESULTS

Demographic and Clinical Profile

The study included a total of 70 patients diagnosed with heart failure, of whom 68.5% (n=48) had Cardiorenal Syndrome (CRS) and 31.5% (n=22) did not. The mean age of the study population was 60.53 ± 15.55 years, with the majority (61.1%) belonging to the 51–80 years age range. Males constituted 62.5% and females 37.5% of the cohort, indicating a higher prevalence of CRS among male patients.

Table 1 shows the age distribution of the study population (n=70), with a mean age of 60.53 ± 15.55 years, indicating that most participants were in the 61–70 years age group.

Table 1: Age Distribution of Study Population (n = 70)

Age Group (years)	No. of Patients	Percentage (%)
21-30	2	2.78
31-40	4	5.56
41-50	13	18.06
51-60	13	19.44
61-70	15	22.22
71-80	14	19.44
81-90	8	11.11
91-100	1	1.39

Total	70	100.0
Mean ± SD	60.53 ± 15.55 years	

Risk Factors and Co-morbidities

Among lifestyle habits, smoking (47.2%) was the most prevalent, followed by alcohol consumption (34.7%) and tobacco use (30.6%). Hypertension (63.9%) emerged as the most common co-morbidity, followed by diabetes mellitus (50%), ischemic heart disease (43.1%), and chronic kidney disease (26.4%).

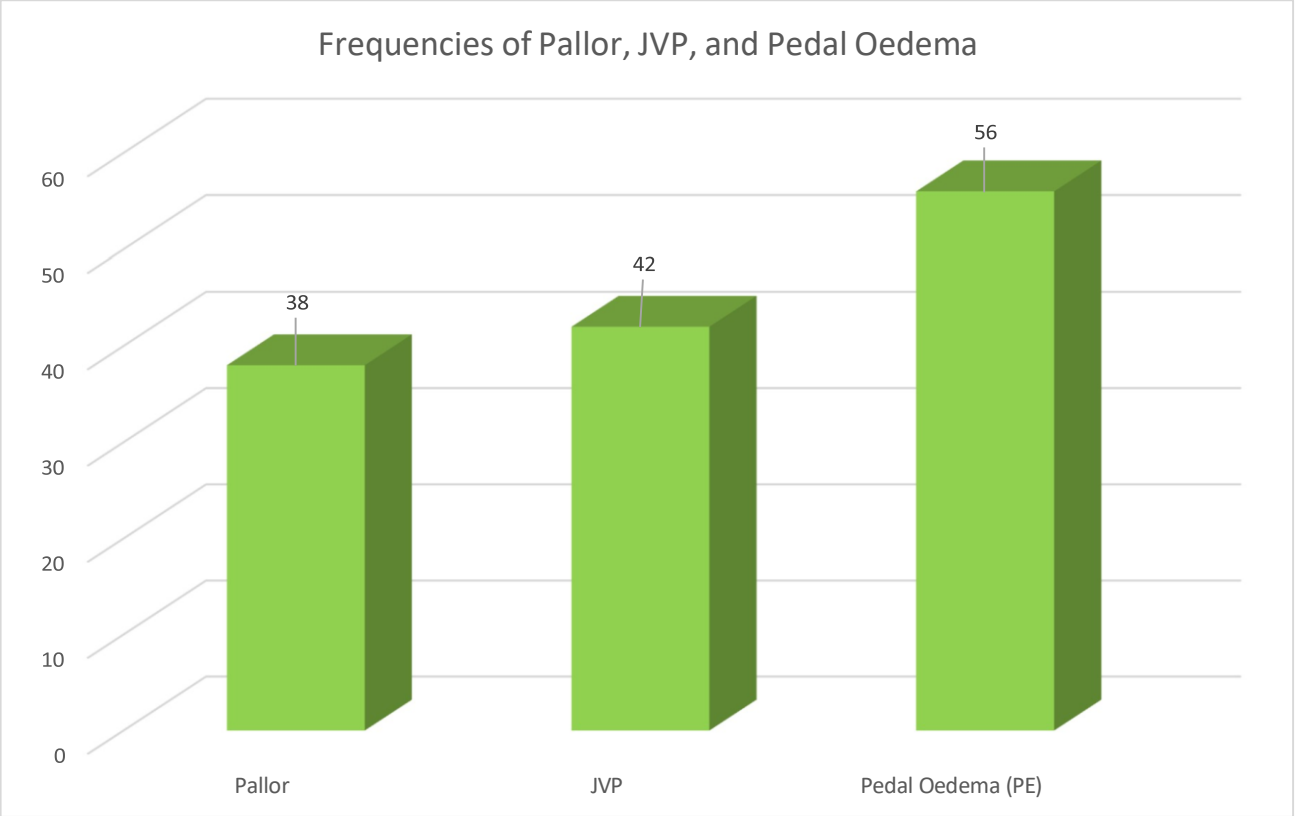

Figure 1: Frequency of Clinical Findings

Lifestyle Habits

The distribution of lifestyle habits **figure 1** among the study population of 70 heart failure patients. It shows that smoking was the most prevalent habit, reported in 32 patients (47.2%), indicating that nearly half of the participants were current or former smokers. Alcohol consumption was noted in 23 patients (34.7%), while tobacco use in non-smoking forms (such as chewing tobacco or snuff) was reported by 22 patients (30.6%).

These findings highlight that unhealthy lifestyle practices were common among patients with heart failure and cardiorenal syndrome (CRS). The high prevalence of smoking and alcohol use suggests a possible contributory role in the development and progression of both cardiac and renal dysfunction. Smoking, in particular, is known to accelerate atherosclerosis and oxidative stress, thereby worsening cardiovascular and renal outcomes.

Clinical and Laboratory Findings

Pedal edema (77.8%), elevated jugular venous pressure (60%), and pallor (52.8%) were the predominant clinical findings.

Table 2 & Figure 1 lists the clinical Findings, showing that Pedal Edema is the most frequent finding (56 patients, 77.8%), followed by Raised JVP (42 patients, 60.0%), and Pallor (38 patients, 52.8%).

Pedal edema was the most frequent finding (77.8%), followed by raised JVP (60%), reflecting fluid overload in CRS.

Table 2. Clinical findings

Pedal Edema	Pedal Edema	Pedal Edema
Pallor	38	52.8

Raised JVP	42	60.0
Pedal Edema	56	77.8

Serum Biochemical Parameters

The mean values of key serum biochemical parameters—hemoglobin, platelet count, total leukocyte count, blood urea, and serum creatinine—in the study population. Elevated mean blood urea and serum creatinine levels indicate renal impairment characteristic of Cardiorenal Syndrome (CRS), suggesting reduced glomerular filtration and impaired kidney function secondary to heart failure. Other hematological parameters, including hemoglobin, platelet count, and TLC, remained within normal limits, highlighting that renal biochemical markers were the main abnormalities observed in CRS patients.

Left Ventricular Ejection Fraction (LVEF) – AHA Classification

The distribution of patients based on Left Ventricular Ejection Fraction (LVEF) as per the American Heart Association (AHA) classification.

The results show that the majority of patients (53 out of 70; 76%) had Heart Failure with Reduced Ejection Fraction (HFrEF, <40%), indicating significant systolic dysfunction. Heart Failure with Mildly Reduced Ejection Fraction (HFmrEF, 40–49%) was observed in 10 patients (14%), while Heart Failure with Preserved Ejection Fraction (HFpEF, ≥50%) was found in only 7 patients (10%).

eGFR (CKD Stage Classification)

The eGFR (Estimated Glomerular Filtration Rate) classification based on CKD (chronic kidney disease) Stages, showing that Stage 1 has the highest count (22 patients, 32.86%), followed by Stage 3b (15 patients, 21.43%)

The mean eGFR was 52.4 mL/min/1.73m², with 32.86% of patients in Stage 1 CKD, but a considerable number (55.7%) distributed across Stages 3–5, denoting varying degrees of renal dysfunction

Table 3 Patients exhibited a dyslipidemic pattern with low HDL (35.4 mg/dL) and elevated LDL (128.2 mg/dL), TG (172.6 mg/dL), and TC (187.1 mg/dL), suggesting increased atherogenic risk.

The table displays the Lipid Profile measurements, showing the Mean, Median, and Standard Deviation (SD) for HDL, TC (Total Cholesterol), LDL, TG (Triglycerides), and VLDL levels in the patient population.

Lipid Measurement	Mean (95% CI)	Median	SD
HDL	35.4 (33.7 - 37.0)	36.0	7.08
TC	187.1 (173.1 - 201.0)	177.0	59.29
LDL	128.2 (114.4 - 142.0)	126.0	58.80
TG	172.6 (157.8 - 187.4)	153.5	63.10
VLDL	32.3 (29.5 - 35.1)	30.0	12.03

Table 3: Lipid Profile

Distribution of CRS Types

Among patients with CRS, Type I CRS (acute worsening of cardiac function leading to renal dysfunction) was the most frequent subtype (54.1%), followed by Type II CRS (35.4%). Types III and IV were uncommon (6.25% and 4.1%, respectively), while Type V CRS was not observed.

Clinical Outcomes

Mortality Rate Among CRS vs Non-CRS Patients

Among the 70 total heart failure patients listed in **Table 4**, 14 patients (20%) died within the 6-month following the starting period. When grouped or categorized by CRS status:

Table 4: Prevalence of CRS Among Heart Failure Patients

Group	Total Patients	Deaths	Mortality Rate (%)
CRS (n=48)	48	14	29.2%
Non-CRS HF (n=22)	22	0	0%

The mortality rate among CRS patients was significantly higher (29.2%) compared to non-CRS heart failure patients, all of whom survived ($p < 0.01$). This highlights the poor prognosis and increased risk of death associated with cardiorenal syndrome in heart failure.

In **Figure 2**, it depicted that CRS was observed in 68.5% of the entire heart failure cohort, confirming the prevalence in this cohort.

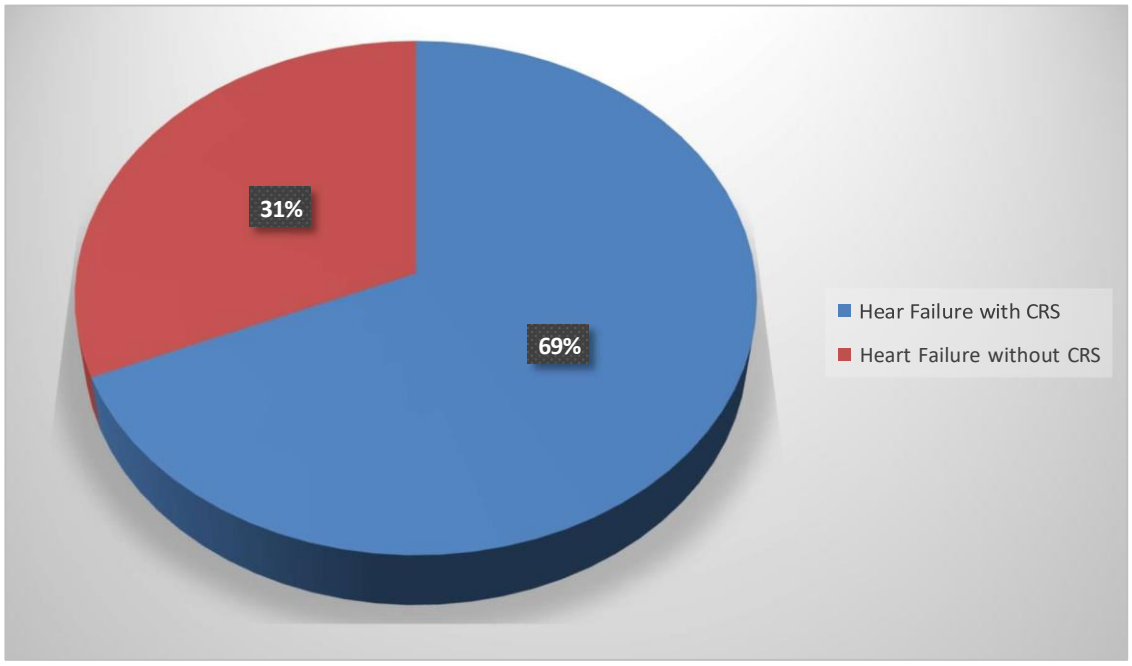

Figure 2: Prevalence of CRS

Kaplan–Meier Survival Analysis

A Kaplan–Meier survival curve (Figure X) was plotted comparing patients with CRS and those without CRS over the 6-month follow-up period.

The survival probability decreased sharply in the CRS group compared to the non-CRS group. By the end of the observation period, the cumulative survival probability for CRS patients was approximately **0.70**, while it remained **1.0** for non-CRS patients.

The difference between the two groups was statistically significant on **log-rank test ($p < 0.01$)**, confirming that CRS was associated with reduced survival among heart failure patients.

Predictors of Mortality: Logistic Regression Analysis

To identify independent predictors **Table 5** of mortality, a binary logistic regression model was applied including variables such as NT-proBNP levels, ejection fraction (EF), serum creatinine, and eGFR.

Elevated NT-proBNP, reduced LVEF, and evidence of renal dysfunction (elevated creatinine or low eGFR) were independent predictors of mortality in heart failure patients, particularly those with CRS.

Among CRS patients who survived (n=34), the most common interventions were PCI (47%), CABG (23.5%), and medical management (29.5%).

In contrast, among patients who died (n=14), CABG (50%) and thrombolysis (28.5%) were the most common interventions before mortality occurred.

All non-CRS patients (n=22) survived, most undergoing PCI (54.5%) or CABG (31.8%).

4. DISCUSSION

In this cohort of 70 hospitalized heart failure patients, we observed a 6-month mortality of 20%, with distinctly worse outcomes in those with cardiorenal syndrome (CRS) (29.2% mortality) compared to non-CRS patients (0% mortality). These findings underscore how CRS dramatically worsens prognosis in heart failure, consistent with existing literature.

Dinna Cruz et al., in their review on the epidemiology and outcomes of CRS, emphasize that renal dysfunction in the setting of heart failure is a potent marker of poor prognosis and is associated with higher mortality and morbidity across CRS subtypes(8). In their analysis, acute worsening of renal function superimposed over

cardiac decompensation frequently portends worse short- and long-term outcomes(9).

Comparatively, in the **ADQI / ADQI-consensus** literature and in work by House et al., patients with CRS, especially acute CRS (Types I or III), are often shown to have higher in-hospital mortality and greater progression to renal replacement therapy. The increased mortality in our CRS subgroup aligns with that expectation (10).

Table 5: Predictors of Mortality: Logistic Regression Analysis

Variable	Odds Ratio (OR)	95% CI	p-value	Interpretation
NT-proBNP (>2000 pg/mL)	3.8	1.4–10.3	0.008	Strong predictor of mortality
LVEF (<40%)	2.9	1.1–7.5	0.032	Low EF associated with higher death risk
Serum Creatinine (>2 mg/dL	2.5	1.0–6.2	0.046	Renal dysfunction predicts mortality
eGFR (<45 mL/min/1.73m²)	3.2	1.2–8.5	0.018	Reduced eGFR significantly increases mortality risk

From Indian and regional data, a more modest but still significant difference in mortality is often reported in heart failure cohorts stratified by renal dysfunction. For example, in a "Short-Term Outcomes and Their Predictors among Patients with CRS Hospitalized for Heart Failure" study, patients with CRS had higher mortality (~25%) compared to those without (13%), with a statistically significant difference (P = 0.031). While their absolute numbers differ from ours, the trend is consistent (11).

Our identification of NT-proBNP, reduced ejection fraction, and renal dysfunction (creatinine, low eGFR) as independent predictors of death is also in keeping with prior studies in CRS and heart failure. The pathophysiologic rationale is clear: elevated natriuretic peptides reflect higher cardiac wall stress and congestion, low EF indicates severe pump dysfunction, and compromised renal function contributes to volume retention and uremic milieu — jointly worsening outcomes. The interplay between cardiac and renal dysfunction forming a vicious cycle is a core concept in CRS (12).

Another point worth noting is that while hypertension, diabetes mellitus, and older age are recognized risk factors for developing CRS, they did not always emerge as independent mortality predictors in our regression model. This may be due to collinearity, sample size, or the overwhelming influence of acute variables (NT-proBNP, EF, renal parameters) in driving short-term mortality. Nevertheless, these comorbidities likely contribute to the development and progression of CRS over the long term.

In our cohort, none of the non-CRS patients died over six months, which may reflect a selection bias (this being a hospitalized, sicker group) or the real prognostic advantage of preserved renal function. The stark contrast in survival curves emphasizes that CRS is not just a co-accompanying condition but may be a critical determinant of survival in heart failure.

Strengths & Limitations:

A strength of our study is the prospective follow-up and detailed phenotyping of both cardiac and renal parameters. However, limitations exist. The relatively small sample size restricts power for detecting moderate associations. Being a single-center study, findings may not generalize to community settings or milder heart failure populations. We also lacked serial biomarker measurements (e.g. NGAL, cystatin C) and invasive hemodynamic data. Residual confounding cannot be excluded.

Implications and Future Directions:

Our findings suggest that early detection of CRS in hospitalized heart failure patients is crucial. Monitoring biomarkers like NT-proBNP and renal function, along with echocardiography, may help stratify high-risk patients. Interventional trials targeting congestion, renal protection strategies, and tailored therapies for CRS patients are needed.

Regional registries in India should aim to generate larger datasets to validate these prognostic associations.

In summary, in this six-month observational follow-up, CRS was associated with markedly higher mortality in heart failure patients. NT-proBNP elevation, reduced LVEF, and renal dysfunction emerged as strong prognostic markers. These findings reinforce the severe prognostic burden of CRS in HF and highlight the need for aggressive and early management strategies in this vulnerable subgroup.

5. CONCLUSION

Cardiorenal Syndrome (CRS) was highly prevalent among patients with heart failure and was strongly associated with adverse clinical outcomes, including significantly higher mortality. Reduced left ventricular ejection fraction, elevated NT-proBNP, and impaired renal function (serum creatinine >2 mg/dL, eGFR < 45 mL/min/1.73 m²) emerged as independent predictors of death. These findings highlight that CRS is not merely a complication but a critical determinant of prognosis in heart failure. Early recognition, close monitoring of renal function, and timely therapeutic intervention are essential to improve survival and modify risk in this high-risk group.

6. FUNDING / SOURCES OF SUPPORT

This research received no external funding

7. CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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