**The Charlson Comorbidity Index for Heart failure with reduced ejection fraction prognosis prediction**

**Abstract**

Heart failure with reduced ejection fraction (HFrEF) remains a leading cause of morbidity and mortality worldwide, with prognosis often worsened by multiple coexisting chronic conditions. The Charlson Comorbidity Index (CCI) is a widely validated tool designed to quantify comorbidity burden and predict mortality risk in various clinical populations. However, its prognostic value in HFrEF patients, particularly in North African settings where patient characteristics and healthcare systems differ, has not been well characterized.

We conducted a prospective, single-center observational study including 188 adult patients diagnosed with HFrEF, defined by a left ventricular ejection fraction below 40%, admitted to the therapeutic heart failure unit at Ibn Rochd Hospital, Casablanca, from March to October 2022. Upon admission, comorbidities were systematically recorded and scored using the CCI. Patients were categorized into two groups based on a CCI cutoff of 5 to assess the impact of comorbidity burden on survival. The primary endpoint was all-cause mortality monitored throughout the follow-up period.

The mean age of the study population was 63 ± 12 years, with a male-to-female ratio of 2:1. The average CCI score was 3.65 ± 1.45 (range 1–8). Hypertension (33.5%), diabetes mellitus (30.3%), and chronic obstructive pulmonary disease (11.7%) were the most prevalent comorbidities. Over the follow-up, 44 patients (23.4%) died. Mortality was significantly higher among patients with a CCI score greater than 5 (p < 0.001). Kaplan-Meier survival analysis demonstrated a mean survival time of 6.02 months (95% CI: 5.94–6.47) in patients with CCI ≤ 5 compared to 4.38 months (95% CI: 3.27–5.50) in those with CCI > 5.

These results highlight the CCI as a simple, reliable prognostic tool for mortality risk stratification in HFrEF patients and suggest its potential utility in guiding individualized clinical management, especially in resource-limited healthcare environments.

**Keywords:** Heart failure with reduced ejection fraction, Charlson Comorbidity Index, mortality prediction, comorbidities, risk stratification, observational study.

# **Introduction**

Heart failure with reduced ejection fraction (HFrEF) remains a major global health concern, with high morbidity, mortality, and frequent hospital readmissions despite therapeutic advances. Recent estimates suggest that more than 64 million individuals are affected worldwide, with HFrEF accounting for nearly half of all cases [1]. While guideline-directed medical therapy has improved outcomes, risk stratification remains challenging due to the heterogeneity of patient profiles [2,3].

One of the main contributors to poor prognosis in HFrEF is the burden of non-cardiac comorbidities. Most patients present with at least three to five chronic conditions such as hypertension, diabetes, chronic kidney disease, or chronic obstructive pulmonary disease (COPD), which negatively impact disease trajectory, limit therapeutic options, and increase susceptibility to adverse events [4,5]. However, assessing these conditions in isolation may underestimate their combined effect.

The Charlson Comorbidity Index (CCI), developed to predict one-year mortality in medical inpatients, provides a composite score based on the presence and severity of 19 chronic conditions [6]. Its simplicity and reliance on clinical data make it appealing for use in heart failure, especially in low-resource settings where advanced risk stratification tools may not be available.

Several recent studies have demonstrated the prognostic value of the CCI in heart failure cohorts. Higher scores have been associated with increased mortality, readmission risk, and worse functional outcomes [7–10]. Nevertheless, most of these data come from Western or Asian populations, and little is known about the utility of the CCI in North African patients with HFrEF [11]. Given regional differences in health systems, disease patterns, and treatment accessibility, validating such tools in local practice is essential.

This study aimed to evaluate the prognostic value of the Charlson Comorbidity Index in predicting all-cause mortality among patients with HFrEF admitted to a specialized heart failure unit in Morocco. We hypothesized that a higher CCI score would be associated with increased mortality risk and shorter survival times, thus supporting its integration into clinical practice for improved patient management.

**Methods**

**Study Design and Setting**
This prospective, single-center observational study was conducted at the therapeutic heart failure (HF) within the cardiology department at Ibn Rochd Hospital, Casablanca, Morocco. Data collection spanned an 8-month period from March 2022 to October 2022. The hospital serves a diverse urban and suburban population, providing a relevant clinical setting for assessing heart failure outcomes in a North African context.

**Study Population**

Eligible participants were adult patients (≥18 years) admitted with a confirmed diagnosis of HFrEF, defined as a left ventricular ejection fraction below 40% on echocardiography. Patients presenting with acute coronary syndromes, recent myocardial infarction (within the past 30 days), or other severe systemic illnesses that could confound the study outcomes were excluded. Informed consent was obtained from all participants prior to enrollment.

**Data Collection**
Upon admission, data were collected on patient demographics, clinical characteristics, and comorbidities. Comorbidities were quantified using the CCI, which assigns weighted scores to specific conditions, resulting in an overall comorbidity score. The primary outcome of interest was all-cause mortality, with patients followed up for survival status over the study period.

**Statistical Analysis**
Data were analyzed using SPSS version 23.0. Patients were dichotomized into two groups based on their CCI score: low comorbidity burden (CCI ≤ 5) and high comorbidity burden (CCI > 5). Continuous variables were expressed as means ± standard deviations, and categorical variables as frequencies and percentages. Survival differences between groups were assessed using Kaplan-Meier survival analysis and compared with the Log-rank test. A p-value < 0.05 was considered statistically significant.

**Ethical Considerations**
This study was approved by the Ethics Committee of Ibn Rochd Hospital, Casablanca. All patients provided informed consent prior to inclusion, in accordance with the principles of the Declaration of Helsinki.

**Results**

**Patient Characteristics**

A total of 188 patients met inclusion criteria and were enrolled. The mean age of the cohort was 63 ± 12 years, with a predominance of male patients (male-to-female ratio approximately 2:1). The average CCI score was 3.65 ± 1.45, with a range of 1 to 8, indicating a variable but generally moderate comorbidity burden among participants.

**Comorbidities**

Hypertension was the most frequently observed comorbidity (33.5%), followed by diabetes mellitus (30.3%) and chronic obstructive pulmonary disease (11.7%). Each comorbidity was analyzed for its association with mortality risk; however, none reached statistical significance individually (hypertension p=0.42, diabetes p=0.89, COPD p=0.9), underscoring the importance of cumulative comorbidity assessment rather than isolated conditions.

**Mortality and Survival Analysis**

During the follow-up period, 44 patients (23.4%) died. Mortality was significantly higher in the high comorbidity group (CCI > 5) compared to the low comorbidity group (CCI ≤ 5), with a highly significant difference (p<0.001). The mean estimated survival time was 6.02 months (95% CI: 5.94–6.47) for patients with lower CCI scores, versus 4.38 months (95% CI: 3.27–5.50) for those with higher scores. Kaplan-Meier survival curves clearly depicted the survival disparity between groups, confirmed by the Log-rank test (p<0.001) (Figure-1). These findings demonstrate that a higher Charlson Comorbidity Index is strongly associated with increased mortality risk in patients with HFrEF.

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### ****Discussion****

Our **prospective observational study** demonstrates that the Charlson Comorbidity Index is a strong and independent predictor of mortality in patients with HFrEF.

Patients with a CCI > 5 experienced significantly higher mortality and shorter survival compared to those with lower scores, supporting the use of this index as a simple yet powerful tool for risk stratification in heart failure care.

These findings are consistent with previous investigations conducted across various healthcare settings worldwide. For example, in the ASCEND-HF trial analysis, each one-point increase in the CCI was associated with a 15% increase in six-month mortality risk [10]. This demonstrates a clear dose-response relationship between comorbidity burden and adverse outcomes in heart failure. Similarly, a recent meta-analysis by Hamid et al. reported that patients in the highest tertile of CCI scores had a 32% higher risk of mortality compared to those with lower scores [8]. Our study reinforces these results by validating the prognostic value of the CCI within a North African context, where epidemiological profiles, healthcare infrastructure, and socioeconomic factors differ substantially from Western populations, and where such data are relatively scarce [11].

Interestingly, despite the high prevalence of common comorbidities such as hypertension, diabetes mellitus, and COPD within our study, these conditions individually did not show a statistically significant association with mortality. This observation underscores the importance of assessing the cumulative burden of comorbidities rather than focusing solely on individual diseases. The CCI effectively captures this cumulative impact, recognizing that multimorbidity creates a vulnerable physiological state marked by systemic inflammation, neurohormonal dysregulation, reduced functional reserve, and decreased tolerance to medications—all contributing to worse clinical outcomes [4,5]. This cumulative effect can amplify the risk beyond what any single comorbidity would predict.

One of the main strengths of the CCI is its simplicity and practicality. Unlike specialized biomarkers such as natriuretic peptides or advanced imaging modalities like cardiac MRI, which may not be readily accessible in many healthcare settings, the CCI can be calculated from basic clinical information obtained at admission [12]. This makes it particularly valuable in resource-limited environments where diagnostic and monitoring tools may be scarce, yet the need for effective risk stratification remains critical. By incorporating the CCI into routine clinical assessment at admission, healthcare providers can quickly identify high-risk patients who may benefit from intensified monitoring, closer follow-up, early discharge planning, or more aggressive management of comorbidities and heart failure symptoms.

Moreover, the CCI should not be viewed as a stand-alone prognostic marker but rather as a complementary tool within a broader risk assessment framework. Previous studies suggest that combining the CCI with heart failure-specific parameters—such as natriuretic peptides (e.g., NT-proBNP), echocardiographic measures of left ventricular function, renal function markers, and assessments of functional capacity—can enhance prognostic accuracy and better inform personalized treatment plans [7,12]. Such multidimensional risk models can help clinicians prioritize patients for advanced therapies, including device implantation or referral for heart transplantation, and also guide timely discussions about palliative care when appropriate.

Despite these promising results, several limitations of our study should be acknowledged. The single-center design and relatively modest sample size may limit the generalizability of our findings to other populations and healthcare settings. Additionally, our follow-up period of six months was relatively short, restricting our ability to capture long-term outcomes and mortality trends. We also did not evaluate the impact of variations in treatment intensity, such as the use of beta-blockers, sacubitril/valsartan, or device therapies, which might independently influence mortality risk irrespective of comorbidity burden. Future studies incorporating these variables will be valuable in further refining the prognostic utility of the CCI.

Future research should also focus on integrating the CCI into electronic health record systems to enable real-time risk assessment and clinical decision support. Moreover, interventional studies targeting patients with high CCI scores are needed to determine whether tailored management strategies can reduce mortality and improve quality of life in this vulnerable subgroup. Importantly, validation of the CCI’s prognostic value in larger, multicenter cohorts across North Africa will be crucial to confirm its widespread applicability and to guide region-specific clinical guidelines.

In conclusion, our findings demonstrate that the Charlson Comorbidity Index is a valuable, simple, and accessible prognostic instrument in patients with HFrEF, independently associated with mortality risk in a Moroccan population. Given its predictive strength, ease of use, and applicability in diverse healthcare environments, particularly those constrained by limited resources, the CCI should be considered as an integral component of routine clinical evaluation and risk stratification in heart failure management.

**Conclusion**

This study underscores the critical importance of systematically assessing comorbidities in patients with HFrEF. The CCI has proven to be a valuable and practical tool for identifying patients at high risk of mortality, demonstrating a strong and independent association between higher CCI scores and increased risk of death.

Considering the high prevalence and complexity of multiple coexisting chronic conditions in this patient population, a thorough evaluation of comorbidity burden should be an integral part of routine clinical practice.Moreover, the significant impact of comorbidities on patient outcomes highlights the urgent need for comprehensive secondary cardiovascular prevention strategies tailored to individuals with elevated CCI scores. These strategies could include optimized medical therapy, vigilant monitoring, multidisciplinary care, and patient education to effectively manage both heart failure and associated comorbid conditions.

Future research should aim to further refine and validate the prognostic value of the CCI in diverse clinical settings and populations, especially in resource-limited environments. Additionally, it is essential to explore targeted interventions that can specifically address the heightened mortality risk linked to a high comorbidity burden. Ultimately, integrating comorbidity assessment tools like the CCI into personalized treatment plans may significantly improve survival and quality of life for patients living with HFrEF.

**List of abreviations**

**HFrEF** - Heart Failure with Reduced Ejection Fraction

**CCI** - Charlson Comorbidity Index

**HF** - Heart Failure

**COPD** - Chronic Obstructive Pulmonary Disease

**DM** - Diabetes Mellitus

**HBP** - High Blood Pressure

**SPSS** - Statistical Package for the Social Sciences

**CI** - Confidence Interval

**SHFM** - Seattle Heart Failure Model

**NT-proBNP** - N-terminal pro B-type Natriuretic Peptide

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