



RESEARCH

Global Immune-Nutrition-Inflammation Index for risk stratification of in-hospital mortality in acute heart failure

Akut kalp yetersizliğinde hastane içi mortalite riskinin belirlenmesinde Global İmmün-Beslenme-İnflamasyon İndeksinin rolü

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Abstract

Purpose: Acute decompensated heart failure (ADHF) is associated with substantial in-hospital mortality and frequent early rehospitalization. This study evaluated the prognostic value of the Global Immune–Nutrition–Inflammation Index (GINI) in hospitalized patients with ADHF.

Materials and Methods: This retrospective single-center study included 197 consecutive patients hospitalized between January 2023 and December 2025. GINI was calculated from admission laboratory parameters. The primary endpoint was in-hospital all-cause mortality. Secondary endpoints were composites of all-cause mortality or heart failure rehospitalization within 30 and 90 days after discharge.

Results: During hospitalization, 26 patients (13.2%) died. Median admission GINI was higher in non-survivors than in survivors (937.7 [469.3–3118.3] vs. 408.8 [80.6–1592.8]). After multivariable adjustment, GINI was not independently associated with in-hospital mortality (adjusted odds ratio [OR], 1.596; 95% confidence interval [CI], 0.900–2.830), whereas log-transformed troponin remained independently associated with mortality (adjusted OR, 2.910; 95% CI, 1.354–6.252). Among 171 patients discharged alive, the composite endpoint occurred in 52 (30.4%) within 30 days and 106 (62.0%) within 90 days. GINI was not independently associated with either post-discharge endpoint after adjustment for N-terminal pro-B-type natriuretic peptide.

Conclusion: Admission GINI reflected increased risk in unadjusted analyses but did not provide independent prognostic information beyond established clinical and cardiac biomarkers.

Keywords: Acute heart failure, global immune–nutrition–inflammation index, inflammation.

Öz

Amaç: Akut dekompanse kalp yetersizliği (ADKY), önemli hastane içi mortalite ve sık erken yeniden yatışla ilişkilidir. Bu çalışmada, ADKY nedeniyle hastaneye yatırılan hastalarda Global Immune–Nutrition–Inflammation Index’in (GINI) prognostik değeri değerlendirildi.

Gereç ve Yöntem: Bu retrospektif, tek merkezli çalışmaya Ocak 2023–Aralık 2025 tarihleri arasında hastaneye yatırılan ardışık 197 hasta dahil edildi. GINI, başvuru sırasındaki laboratuvar parametrelerinden hesaplandı. Birincil sonlanım noktası hastane içi tüm nedenlere bağlı mortaliteydi. İkincil sonlanım noktaları, taburculuk sonrası 30 ve 90 gün içinde tüm nedenlere bağlı ölüm veya kalp yetersizliği nedeniyle yeniden yatıştan oluşan kompozit sonlanımlardı.

Bulgular: Hastane yatışı sırasında 26 hasta (%13,2) öldü. Ortanca başvuru GINI değeri ölenlerde yaşayanlardan daha yüksekti (937,7 [469,3–3118,3] ve 408,8 [80,6–1592,8]). Çok değişkenli düzeltme sonrasında GINI hastane içi mortaliteyle bağımsız olarak ilişkili değildi (düzeltilmiş olasılıklar oranı [OR], 1,596; %95 güven aralığı [GA], 0,900–2,830); logaritmik dönüşüm uygulanmış troponin ise mortaliteyle bağımsız olarak ilişkiliydi (düzeltilmiş OR, 2,910; %95 GA, 1,354–6,252). Taburcu edilen 171 hastanın 52’sinde (%30,4) 30 gün, 106’sında (%62,0) 90 gün içinde kompozit sonlanım gelişti. GINI, N-terminal pro-B-tipi natriüretik peptit için düzeltme sonrasında her iki taburculuk sonrası sonlanımla da bağımsız olarak ilişkili değildi.

Sonuç: Başvuru GINI değeri düzeltilmemiş analizlerde artmış riski yansıtmakla birlikte, yerleşik klinik ve kardiyak belirteçlerden bağımsız prognostik bilgi sağlamadı.

Anahtar kelimeler: Akut kalp yetersizliği, küresel bağışıklık-beslenme-iltihap indeksi (GINI).

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INTRODUCTION

Heart failure (HF) remains a major global health problem and is among the leading causes of hospitalization, mortality, and healthcare costs, particularly in older adults¹. Despite advances in guideline-directed medical therapy, patients hospitalized with acute decompensated heart failure (ADHF) continue to experience considerable in-hospital mortality and frequent adverse events shortly after discharge^{2,3}. The clinical heterogeneity of ADHF and its complex course make early risk stratification essential for identifying high-risk patients and guiding monitoring and treatment decisions. Several clinical risk scores and cardiac biomarkers, including the Meta-Analysis Global Group in Chronic Heart Failure (MAGGIC) risk score, cardiac troponin, and N-terminal pro-B-type natriuretic peptide (NT-proBNP), are used for prognostic assessment; however, no single measure fully captures the multiple pathophysiological processes influencing outcomes in ADHF⁴.

In addition to hemodynamic impairment and neurohormonal activation, HF is characterized by persistent systemic inflammation, immune dysregulation, oxidative stress, and progressive nutritional deterioration⁵. Activation and recruitment of inflammatory cells contribute to myocardial injury, adverse ventricular remodeling, endothelial dysfunction, and disease progression⁶. Malnutrition and hypoalbuminemia may further increase vulnerability by reflecting impaired metabolic reserve, systemic congestion, and advanced disease. Accordingly, biomarkers integrating inflammatory, immune, and nutritional components may provide a broader representation of the biological disturbances accompanying ADHF than isolated laboratory parameters⁷.

The Global Immune–Nutrition–Inflammation Index (GINI) is a recently proposed composite index calculated using C-reactive protein, neutrophil, monocyte, platelet, lymphocyte, and serum albumin values. By combining markers of systemic inflammation, immune-cell balance, and nutritional status, GINI may offer an inexpensive and readily obtainable measure derived from routine admission laboratory tests. Previous studies have demonstrated associations between elevated GINI and adverse

outcomes in ST-segment elevation myocardial infarction, coronary slow-flow phenomenon, and several malignancies^{8,9,10,11}. Nevertheless, evidence regarding its prognostic role in ADHF remains limited. In particular, it is unclear whether GINI is independently associated with in-hospital mortality and early post-discharge events or provides incremental information beyond established clinical risk scores and cardiac biomarkers.

Therefore, this study aimed to evaluate the association of admission GINI with in-hospital all-cause mortality and 30- and 90-day post-discharge adverse outcomes in patients hospitalized with ADHF. The study also compared the discriminatory performance of GINI with the MAGGIC risk score and examined whether their combination improved mortality risk stratification. We hypothesized that higher admission GINI values would be associated with increased in-hospital mortality and early post-discharge adverse outcomes and would provide incremental prognostic information beyond established clinical risk scores and cardiac biomarkers. By examining in-hospital and early post-discharge outcomes within the same cohort and interpreting GINI alongside MAGGIC, troponin, and NT-proBNP, this study sought to clarify the potential clinical contribution of GINI in ADHF risk assessment.

MATERIALS AND METHODS

Sample

This retrospective single-center study screened consecutive adult patients hospitalized with acute decompensated heart failure (ADHF) in the Department of Cardiology of Kayseri City Training and Research Hospital between January 2023 and December 2025. Acute heart failure was diagnosed according to the 2021 European Society of Cardiology (ESC) Guidelines (3). Of the 210 patients screened for eligibility, 13 were excluded: one because of active hematological malignancy, one because of chronic inflammatory or autoimmune disease, two because of active infection, one because of recent major bleeding or surgery, and eight because of incomplete laboratory data required for GINI calculation. Consequently, 197 patients were included in the final analysis.

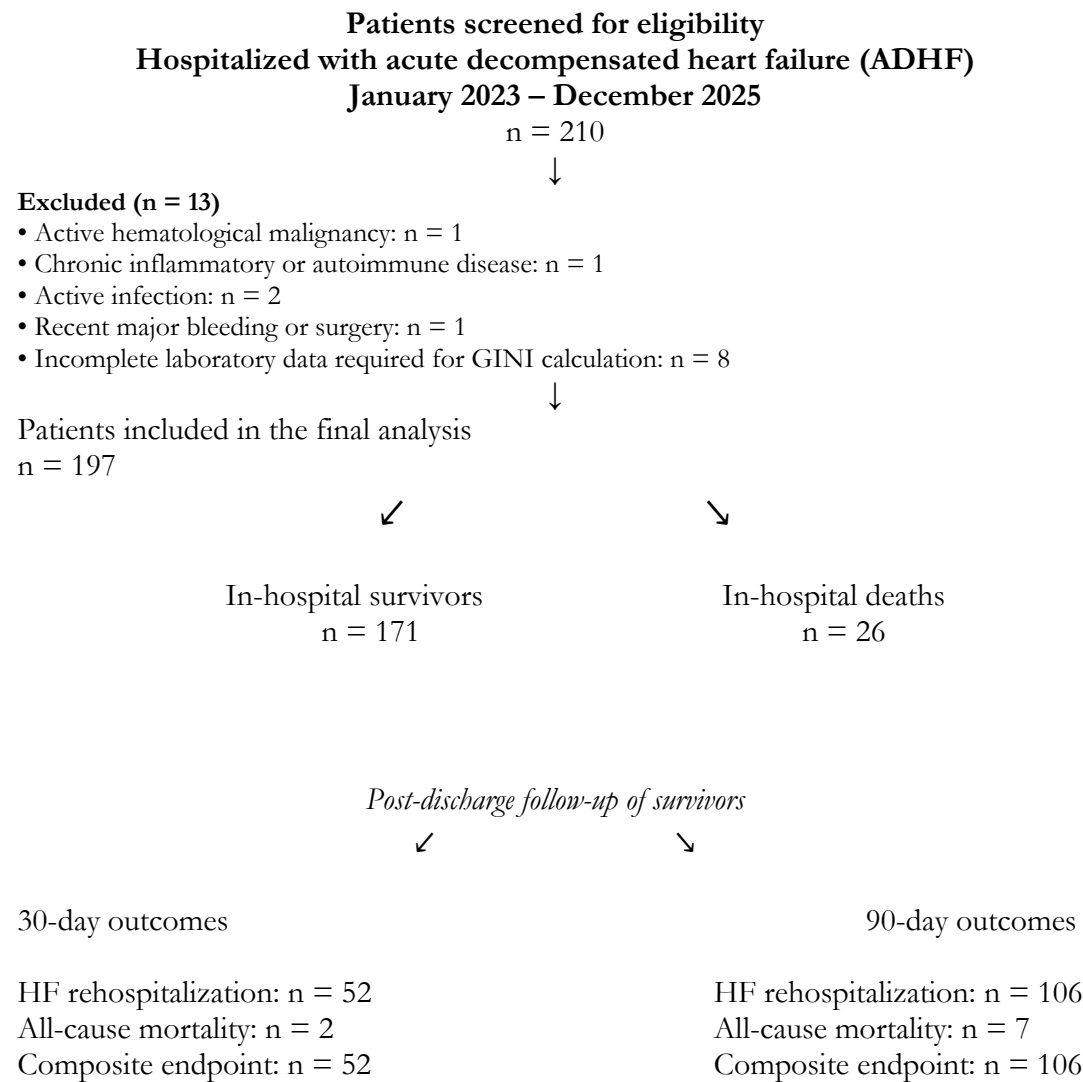


Figure 1. Patient flow diagram
Note: All post-discharge deaths occurred during a heart failure-related rehospitalization. Patients experiencing both events were counted only once in the composite endpoint.

Procedure

The study protocol was approved by the Kayseri City Training and Research Hospital Clinical Research Ethics Committee on December 2, 2025 (approval no. 685) and was conducted in accordance with the Declaration of Helsinki.

Demographic characteristics, medical history, cardiovascular comorbidities, admission vital signs, echocardiographic findings, laboratory results, baseline medical therapy, and follow-up data were retrospectively retrieved from the hospital electronic medical records. Height and body weight were measured at hospital admission by the nursing staff, and body mass index was calculated as weight in kilograms divided by height in meters squared. Blood

pressure was measured at admission using an automated sphygmomanometer after an appropriate resting period. Current smoking was defined as active cigarette use at the time of admission. Comorbidities were identified from documented diagnoses in the electronic medical records, regular medication use, and available clinical and laboratory findings. New York Heart Association functional class was assigned by the responsible cardiologist according to symptom severity and limitation of physical activity.

Laboratory measures

Blood samples were obtained from an antecubital vein at hospital admission before the initiation of in-hospital treatment and were promptly transferred to the central laboratory of Kayseri City Training and Research Hospital. Laboratory analyses included complete blood count, serum sodium, creatinine, albumin, C-reactive protein (CRP), cardiac troponin, and N-terminal pro-B-type natriuretic peptide (NT-proBNP). Samples collected for complete blood count analysis were placed in tubes containing ethylenediaminetetraacetic acid and analyzed using an automated Sysmex hematology analyzer (Sysmex Corporation, Kobe, Japan). Serum samples were separated by centrifugation and analyzed using the Roche Cobas 8000 modular analyzer system (Roche Diagnostics, Mannheim, Germany). Serum albumin was measured using a routine colorimetric method, and CRP was determined using an immunoturbidimetric method. Cardiac troponin and NT-proBNP concentrations were measured using automated electrochemiluminescence immunoassays. All measurements were performed using the manufacturers' reagents and according to the laboratory's routine internal and external quality-control procedures.

Transthoracic echocardiographic examinations

Transthoracic echocardiographic examinations were performed by two cardiologists (Mustafa Gök and Mehmet Kamil Teber) at the Department of Cardiology of Kayseri City Training and Research Hospital. Heart failure phenotypes were classified according to left ventricular ejection fraction (LVEF) as heart failure with reduced ejection fraction (HFrEF; LVEF $\leq 40\%$), mildly reduced ejection fraction (HFmrEF; LVEF 41–49%), and preserved ejection fraction (HFpEF; LVEF $\geq 50\%$).

Baseline guideline-directed medical therapy, including angiotensin-converting enzyme inhibitors (ACE inhibitors), angiotensin receptor blockers

(ARBs), beta-blockers, mineralocorticoid receptor antagonists (MRAs), sodium-glucose cotransporter-2 (SGLT2) inhibitors, loop diuretics, oral anticoagulants, and statins, was also recorded.

The responsible cardiology team managed all patients according to their clinical condition and the recommendations of the 2021 European Society of Cardiology guidelines for acute and chronic heart failure. No study-specific intervention or treatment protocol was applied. Clinical assessment, laboratory testing, and transthoracic echocardiography were performed as part of routine institutional care, and the relevant data were retrospectively retrieved from the hospital electronic medical records.

GINI and MAGGIC score

The Meta-Analysis Global Group in Chronic Heart Failure (MAGGIC) risk score was calculated using the original validated model described by Pocock et al². It was calculated for each patient using 13 routinely available clinical variables: age, sex, body mass index, systolic blood pressure, left ventricular ejection fraction, serum creatinine, New York Heart Association functional class, smoking status, diabetes mellitus, chronic obstructive pulmonary disease, duration of heart failure, beta-blocker use, and angiotensin-converting enzyme inhibitor or angiotensin receptor blocker use. The total score was obtained by summing the points assigned to each variable, with higher scores indicating a greater predicted mortality risk.

The Global Immune–Nutrition–Inflammation Index (GINI) was calculated according to the formula proposed by Karakurt et al⁸.

$$\text{GINI} = (\text{CRP} \times \text{Neutrophil} \times \text{Monocyte} \times \text{Platelet}) / (\text{Albumin} \times \text{Lymphocyte})$$

Albumin was expressed as g/L, CRP as mg/L, and blood cell counts as $\times 10^3/\mu\text{L}$.

Study outcomes and follow-up

The primary outcome was in-hospital all-cause mortality. The secondary outcomes were composite endpoints comprising all-cause mortality or heart failure rehospitalization within 30 and 90 days after hospital discharge. Patients who experienced both events within the relevant follow-up period were counted only once in the composite endpoint. Heart failure rehospitalization was defined as hospital readmission due to worsening heart failure. Follow-up data were obtained from hospital records, the

National Electronic Health Database, and telephone interviews when necessary.

Statistical analysis

Statistical analyses were performed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Because of the retrospective design, all consecutive eligible patients admitted during the predefined study period were included. The final cohort comprised 197 patients, including 26 in-hospital deaths. A sensitivity analysis conducted using a two-sided α level of 0.05 and the observed event rate indicated that the available sample provided approximately 80% power to detect an odds ratio of 1.90 or greater per one-standard-deviation increase in a continuous predictor.

Continuous variables were expressed as mean $\pm$ standard deviation or median (interquartile range), according to data distribution, while categorical variables were presented as number (percentage). Between-group comparisons were performed using the independent-samples *t* test or the Mann–Whitney *U* test for continuous variables and the χ^2 test or Fisher's exact test for categorical variables, as appropriate.

Because GINI values showed a markedly right-skewed distribution, we applied a log₁₀ transformation before regression analyses. We first performed univariable logistic regression analyses to identify variables associated with in-hospital mortality. Variables associated with in-hospital mortality in the univariable analysis, together with clinically relevant covariates including the MAGGIC risk score and log-transformed troponin level, were considered for inclusion in the multivariable logistic regression model. Because only 26 in-hospital deaths occurred, we constructed a parsimonious model to minimize the risk of overfitting. Results are reported as odds ratios (ORs) with 95% confidence intervals (CIs).

Receiver operating characteristic (ROC) curve analysis was performed to evaluate the discriminative performance of the GINI score, the MAGGIC risk score, and the combined MAGGIC–GINI model for predicting in-hospital mortality. Areas under the curve (AUCs) with corresponding 95% confidence intervals were calculated. Patients were also

categorized into tertiles according to admission GINI values for exploratory analyses of in-hospital mortality.

We constructed separate logistic regression models for the 30- and 90-day post-discharge composite endpoints. Because of their right-skewed distributions, GINI and NT-proBNP were analyzed after log₁₀ transformation. Both log-transformed GINI and log-transformed NT-proBNP were included in the adjusted post-discharge models. A two-sided *P* value < 0.05 was considered statistically significant.

RESULTS

A total of 210 patients hospitalized with acute decompensated heart failure (ADHF) were screened for eligibility. After application of the predefined exclusion criteria, 197 patients were included in the final analysis (Figure 1). The mean age was 69.5 ± 11.6 years, and 137 patients (69.5%) were male. Overall, 179 patients (90.9%) presented with NYHA functional class III–IV symptoms. During the index hospitalization, 26 patients (13.2%) died.

Baseline demographic characteristics and comorbidities were generally comparable between survivors and non-survivors. Age, sex, body mass index, smoking status, left ventricular ejection fraction, heart failure phenotype, and the prevalence of major comorbidities did not differ significantly between the groups (all *P* > 0.05). Similarly, baseline medical therapy was comparable, except for a lower frequency of NOAC use among non-survivors.

Among laboratory variables, non-survivors had significantly higher white blood cell, neutrophil, serum creatinine, troponin, and NT-proBNP levels than survivors, whereas serum sodium, albumin, C-reactive protein, lymphocyte count, monocyte count, and platelet count were similar between the groups. Non-survivors also had significantly higher NLR, SII, GINI, and MAGGIC scores, whereas PNI did not differ significantly. Mean LVEF was $31.1 \pm 2.6\%$ in patients with HF_rEF, $44.6 \pm 1.3\%$ in those with HF_{mr}EF, and $55.0 \pm 0.0\%$ in those with HF_{pf}EF. The weighted mean LVEF across the three phenotypes was $34.2 \pm 7.7\%$. Detailed baseline characteristics are presented in Table 1.

Table 1. Baseline clinical characteristics, heart failure characteristics, laboratory findings, inflammatory indices, and medical therapy according to in-hospital mortality

Variable	Overall (n=197)	Survivors (n=171)	Non-survivors (n=26)	P value
Demographic and Clinical Characteristics				
Age, years	69.5 ± 11.6	69.4 ± 11.6	70.1 ± 11.9	0.796
Male sex, n (%)	137 (69.5)	116 (67.8)	21 (80.8)	0.182
Body mass index, kg/m ²	26.2 [24.2–29.8]	26.2 [24.2–29.6]	26.9 [24.5–30.7]	0.776
Current smoking, n (%)	91 (46.2)	79 (46.2)	12 (46.2)	0.997
NYHA class III–IV, n (%)	179 (90.9)	154 (90.1)	25 (96.2)	0.477
Systolic blood pressure, mmHg	131.7 ± 31.4	133.0 ± 30.9	123.2 ± 34.1	0.138
Diastolic blood pressure, mmHg	80.2 ± 18.3	80.4 ± 18.1	79.1 ± 19.7	0.730
Heart rate, beats/min	102.0 [88.0–114.0]	101.0 [87.0–113.0]	104.5 [96.2–118.8]	0.116
Heart Failure Characteristics				
LVEF, %	34.2 ± 7.7	34.4 ± 7.7	33.0 ± 7.5	0.378
Heart failure phenotype, n (%)				0.594
• HFpEF	16 (8.1)	14 (8.2)	2 (7.7)	
• HFmrEF	18 (9.1)	17 (9.9)	1 (3.8)	
• HFrEF	163 (82.7)	140 (81.9)	23 (88.5)	
Comorbidities				
Hypertension, n (%)	150 (76.1)	129 (75.4)	21 (80.8)	0.552
Diabetes mellitus, n (%)	79 (40.1)	71 (41.5)	8 (30.8)	0.297
Coronary artery disease, n (%)	121 (61.4)	105 (61.4)	16 (61.5)	0.989
Atrial fibrillation, n (%)	69 (35.0)	59 (34.5)	10 (38.5)	0.693
Chronic kidney disease, n (%)	49 (24.9)	41 (24.0)	8 (30.8)	0.455
Chronic obstructive pulmonary disease, n (%)	69 (35.0)	61 (35.7)	8 (30.8)	0.625
Laboratory Parameters				
Hemoglobin, g/dL	12.8 ± 2.1	12.9 ± 2.1	12.7 ± 2.2	0.783
White blood cell count, ×10 ³ /μL	9.71 [7.72–13.72]	9.21 [7.64–12.34]	15.94 [10.60–18.68]	<0.001
Neutrophil count, ×10 ³ /μL	7.18 [5.43–10.76]	6.69 [5.11–9.86]	12.11 [8.31–16.63]	<0.001
Lymphocyte count, ×10 ³ /μL	1.33 [0.88–2.11]	1.36 [0.88–2.18]	1.21 [1.02–1.80]	0.351
Monocyte count, ×10 ³ /μL	0.70 [0.53–0.97]	0.70 [0.53–0.97]	0.76 [0.56–1.07]	0.243
Platelet count, ×10 ³ /μL	234.0 [178.0–295.0]	239.0 [178.0–297.0]	207.0 [171.2–267.8]	0.304
Serum sodium, mmol/L	135.7 ± 4.3	135.8 ± 4.2	135.0 ± 5.3	0.364
Serum creatinine, mg/dL	1.26 [0.99–1.69]	1.25 [0.95–1.56]	1.69 [1.11–1.95]	0.035
Serum albumin, g/L	37.2 ± 5.3	37.1 ± 5.0	37.6 ± 7.2	0.738
C-reactive protein, mg/L	17.5 [7.6–49.2]	17.2 [7.3–48.0]	24.0 [10.3–54.6]	0.323
Troponin, ng/L	55.7 [29.8–144.7]	50.5 [27.7–131.0]	115.1 [50.4–306.4]	0.001
NT-proBNP, pg/mL	5789 [2582–15188]	4935 [2533–14475.5]	10776.5 [5336.2–21462.8]	0.031
Inflammatory and Nutritional Indices				
NLR	5.28 [3.15–9.12]	4.95 [3.03–8.23]	11.20 [4.90–16.15]	<0.001
SII	1277.3 [714.0–2064.1]	1210.3 [696.5–1901.9]	2415.1 [1112.3–3174.1]	0.002
PNI	45.6 ± 8.3	45.6 ± 8.1	45.5 ± 9.7	0.971
GINI score	463.4 [89.9–1829.4]	408.8 [80.6–1592.8]	937.7 [469.3–3118.3]	0.012
MAGGIC risk score	15.3 ± 4.4	15.0 ± 4.2	17.2 ± 5.3	0.022
Baseline Medical Therapy				
ACE inhibitor, n (%)	103 (52.3)	89 (52.0)	14 (53.8)	0.864
Angiotensin receptor blocker, n (%)	18 (9.2)	17 (10.0)	1 (3.8)	0.477
Beta-blocker, n (%)	150 (76.5)	132 (77.2)	18 (72.0)	0.567
Mineralocorticoid receptor antagonist, n (%)	79 (40.3)	67 (39.4)	12 (46.2)	0.514
SGLT2 inhibitor, n (%)	31 (15.8)	27 (15.9)	4 (15.4)	1.000
Loop diuretic, n (%)	117 (60.0)	101 (59.8)	16 (61.5)	0.863
NOAC, n (%)	35 (17.8)	34 (19.9)	1 (3.8)	0.053
Statin, n (%)	44 (22.3)	38 (22.2)	6 (23.1)	0.922

Data are presented as mean ± SD, median (IQR), or n (%), as appropriate.

SD, standard deviation; IQR, interquartile range; BMI, body mass index; NYHA, New York Heart Association; LVEF, left ventricular ejection fraction; HFpEF, heart failure with preserved ejection fraction; HFmrEF, heart failure with mildly reduced ejection fraction; HFrEF, heart failure with reduced ejection fraction; WBC, white blood cell; CRP, C-reactive protein; NT-proBNP, N-terminal pro-B-type natriuretic peptide; NLR, neutrophil-to-lymphocyte ratio; SII, systemic immune-inflammation index; PNI, prognostic nutritional index; GINI, Global Immune-Nutrition-Inflammation Index; MAGGIC, Meta-Analysis Global Group in Chronic Heart Failure; ACE, angiotensin-converting enzyme; ARB, angiotensin receptor blocker; MRA, mineralocorticoid receptor antagonist; SGLT2, sodium-glucose cotransporter-2; NOAC, non-vitamin K antagonist oral anticoagulant.

Among the 171 patients discharged alive, heart failure rehospitalization occurred in 52 patients (30.4%) within 30 days and in 106 patients (62.0%) within 90 days. All-cause mortality occurred in 2 patients (1.2%) and 7 patients (4.1%) at 30 and 90 days, respectively. The composite endpoint occurred in 52 patients (30.4%) at 30 days and in 106 patients (62.0%) at 90 days. All post-discharge deaths occurred during a heart failure-related rehospitalization; therefore, patients experiencing both events were counted only once in the composite endpoint (Table 2).

Table 2. Thirty-day and ninety-day post-discharge clinical outcomes among patients discharged alive

Outcome	Events, n (%)
30-day outcomes (n = 171)	
Heart failure rehospitalization	52 (30.4)
All-cause mortality	2 (1.2)
Composite endpoint†	52 (30.4)
90-day outcomes (n = 171)	
Heart failure rehospitalization	106 (62.0)
All-cause mortality	7 (4.1)
Composite endpoint†	106 (62.0)

Data are presented as number (%). Thirty-day and ninety-day outcomes were evaluated only among patients who survived the index hospitalization (n = 171). Patients who died during the index hospitalization (n = 26) were excluded from all post-discharge analyses.

† Composite endpoint was defined as the occurrence of all-cause mortality or heart failure rehospitalization during follow-up. Rehospitalization refers to readmission due to worsening heart failure

HF, heart failure.

In the adjusted post-discharge models, log-transformed GINI was not independently associated with either the 30-day composite endpoint (adjusted OR 1.382, 95% CI 0.883–2.161; $P=0.156$) or the 90-day composite endpoint (adjusted OR 0.711, 95% CI 0.464–1.088; $P=0.116$). In contrast, log-transformed NT-proBNP was independently associated with both the 30-day (adjusted OR 2.200, 95% CI 1.038–4.665; $P=0.040$) and 90-day composite endpoints (adjusted OR 3.883, 95% CI 1.820–8.285; $P<0.001$).

In the univariable logistic regression analysis, troponin, NT-proBNP, MAGGIC score, and GINI score were associated with in-hospital mortality. However, after multivariable adjustment, only log-transformed troponin remained independently associated with in-hospital mortality (adjusted OR 2.910, 95% CI 1.354–6.252, $P = 0.006$), whereas serum creatinine, MAGGIC score, and log-

transformed GINI were no longer significant predictors (Table 3).

Table 3. Univariable and multivariable logistic regression analyses for in-hospital mortality

A. Univariable logistic regression analysis

Variable	OR (95% CI)	P value
Age (per year)	1.005 (0.969–1.042)	0.795
Male sex	0.502 (0.180–1.402)	0.189
Body mass index (per kg/m ²)	1.008 (0.923–1.101)	0.858
Serum creatinine (per mg/dL)	1.188 (0.774–1.823)	0.430
Serum sodium (per mmol/L)	0.958 (0.873–1.051)	0.362
Troponin	1.001 (1.000–1.001)	0.023
NT-proBNP	1.00003 (1.00000–1.00006)	0.088
MAGGIC risk score	1.115 (1.014–1.227)	0.025
GINI score	1.00008 (1.00001–1.00014)	0.030

B. Multivariable logistic regression analysis

Variable	Adjusted OR (95% CI)	P value
Serum creatinine	0.889 (0.501–1.580)	0.689
Troponin (log10)	2.910 (1.354–6.252)	0.006
MAGGIC risk score	1.083 (0.974–1.203)	0.140
GINI score (log10)	1.596 (0.900–2.830)	0.110

Data are presented as odds ratios (ORs) with 95% confidence intervals (CIs). Variables with $P < 0.10$ in the univariable analysis and clinically relevant covariates were considered for multivariable analysis. Given the limited number of in-hospital deaths (n = 26), a parsimonious multivariable logistic regression model was constructed to minimize overfitting. Troponin and GINI were analyzed after log10 transformation because of their right-skewed distributions

OR, odds ratio; CI, confidence interval; MAGGIC, Meta-Analysis Global Group in Chronic Heart Failure; GINI, Global Immune-Nutrition-Inflammation Index; NT-proBNP, N-terminal pro-B-type natriuretic peptide.

Receiver operating characteristic analysis demonstrated modest discrimination for in-hospital mortality. The combined MAGGIC–GINI model showed the highest predictive performance (AUC 0.674, 95% CI 0.549–0.788), followed by GINI alone (AUC 0.653, 95% CI 0.534–0.767) and the MAGGIC score alone (AUC 0.622, 95% CI 0.492–0.748) (Table 4).

Table 4. Receiver Operating Characteristic (ROC) Analysis of GINI, MAGGIC score, and the combined MAGGIC–GINI model for predicting in-hospital mortality

Model	AUC	95% CI
GINI	0.653	0.534–0.767
MAGGIC	0.622	0.492–0.748
MAGGIC + GINI	0.674	0.549–0.788

Values are presented as area under the receiver operating characteristic curve (AUC) with corresponding 95% confidence intervals (CIs). The combined MAGGIC–GINI model was generated by multivariable logistic regression including both the MAGGIC risk score and log-transformed GINI.

AUC, area under the curve; CI, confidence interval; GINI, Global Immune–Nutrition–Inflammation Index; MAGGIC, Meta-Analysis Global Group in Chronic Heart Failure.

DISCUSSION

The present study evaluated the prognostic value of the Global Immune–Nutrition–Inflammation Index (GINI) in patients hospitalized with ADHF and explored its relationship with both in-hospital and early post-discharge outcomes. Three main findings emerged from our analyses. First, admission GINI values were significantly higher in patients who died during hospitalization and were associated with in-hospital mortality in the univariable analysis. Second, after adjustment for established clinical and biochemical risk markers, including the MAGGIC risk score and troponin, GINI was no longer independently associated with mortality, whereas troponin remained an independent predictor. After adjustment for NT-proBNP, admission GINI was not independently associated with the 30- or 90-day post-discharge composite endpoint, whereas NT-proBNP remained independently associated with both endpoints. Third, the combined MAGGIC–GINI model showed the highest discriminatory performance, although its improvement over the individual models was modest. Together, these findings suggest that GINI reflects the inflammatory, immune, and nutritional disturbances accompanying acute decompensated heart failure, but provides limited prognostic information beyond established clinical and cardiac biomarkers.

Heart failure is increasingly recognized as a systemic syndrome characterized not only by hemodynamic impairment but also by persistent inflammation, immune activation, endothelial dysfunction, and adverse ventricular remodeling¹². These interconnected processes contribute to disease progression and are closely associated with poor clinical outcomes. Consequently, growing interest has

focused on composite inflammatory biomarkers that integrate multiple biological pathways rather than isolated laboratory parameters, as they may provide a more comprehensive assessment of the biological burden accompanying acute heart failure¹³.

GINI combines inflammatory, immune, and nutritional parameters into a single index and may therefore better reflect the complex pathophysiological processes underlying acute heart failure. In addition, congestion-related intestinal dysfunction and impaired gut barrier integrity may further amplify systemic inflammation and metabolic abnormalities during acute decompensation¹⁴. Interestingly, although individual GINI components, including C-reactive protein and serum albumin, did not differ significantly between survivors and non-survivors, the composite GINI score was significantly higher in patients who died during hospitalization. This finding suggests that the prognostic value of GINI arises from the cumulative interaction of inflammatory, immune, and nutritional pathways rather than from the contribution of any single laboratory parameter. In our cohort, NLR and SII were also associated with in-hospital mortality, supporting the concept that composite inflammatory indices may provide greater prognostic information than isolated laboratory parameters in patients with ADHF^{7,13}.

Clinical evidence regarding the prognostic significance of GINI remains limited, particularly in heart failure populations. Previous studies have demonstrated its association with adverse outcomes in patients with ST-segment elevation myocardial infarction, coronary slow-flow phenomenon, and several malignancies^{8,9,10,11}. Our findings extend the current evidence by showing that GINI is associated with in-hospital mortality in patients hospitalized with ADHF, although its prognostic information appears to overlap with established clinical and biochemical risk markers. To our knowledge, this is among the first studies evaluating GINI in an acute heart failure population.

Another important finding was the independent prognostic role of troponin. Elevated troponin concentrations in acute heart failure likely reflect ongoing myocardial injury caused by increased ventricular wall stress, impaired coronary microcirculation, oxidative stress, and neurohormonal activation rather than acute coronary occlusion alone^{15,16,17}. Our findings support the

concept that myocardial injury is a major determinant of short-term prognosis during ADHF.

Although GINI was associated with the 30-day composite endpoint in the univariable analysis, it was not independently associated with either the 30- or 90-day composite endpoint after adjustment for NT-proBNP. This observation suggests that a single baseline GINI measurement primarily reflects the acute inflammatory and metabolic disturbances accompanying hospitalization rather than the mechanisms driving outcomes after discharge. Post-discharge prognosis is influenced by multiple factors, including residual congestion, ventricular dysfunction, optimization of guideline-directed medical therapy, and long-term disease progression. Therefore, admission GINI alone may have limited value for predicting clinical events beyond the index hospitalization^{16,17,18}.

The MAGGIC score remains one of the most extensively validated prognostic models in heart failure⁴. Although both MAGGIC and GINI were associated with in-hospital mortality in the univariable analyses, neither remained independently associated with mortality after multivariable adjustment. Receiver operating characteristic analysis demonstrated that the combined MAGGIC–GINI model achieved the highest discriminative performance, although the improvement over either model alone was modest. These findings suggest that GINI should be considered an adjunctive biomarker that complements, rather than replaces, established heart failure risk assessment tools.

From a clinical perspective, GINI offers a simple and inexpensive assessment of inflammatory and nutritional status using routinely available laboratory parameters. Although it did not provide independent prognostic information beyond established risk markers in the present study, it may still contribute to the early identification of patients with greater biological vulnerability at hospital admission. Whether serial GINI measurements or incorporation of GINI into existing heart failure risk models improves risk prediction warrants further investigation.

This study has several limitations. First, its retrospective single-center design may limit the generalizability of the findings. Second, the relatively small number of in-hospital deaths restricted the complexity of the multivariable models. Third, GINI was assessed only at hospital admission, and serial

measurements were not available. Finally, larger prospective multicenter studies are needed to validate the prognostic value of GINI in patients with acute heart failure. In addition, subgroup analyses according to heart failure phenotype were not performed because of the relatively limited sample size, which may have limited the ability to detect phenotype-specific associations.

In conclusion, higher admission GINI values were associated with in-hospital mortality in unadjusted analyses but did not remain independently associated with in-hospital or early post-discharge outcomes after adjustment for established clinical and cardiac biomarkers. These findings suggest that GINI reflects the inflammatory, immune, and nutritional disturbances accompanying ADHF but provides limited incremental prognostic information beyond conventional risk markers. Future prospective multicenter studies with larger cohorts should evaluate whether serial GINI measurements, rather than a single admission value, improve risk stratification and should externally validate its incremental value alongside established clinical risk scores and cardiac biomarkers before routine clinical implementation.

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