

Admission Red Cell Distribution Width-to-Albumin Ratio Predicts In-Hospital Mortality in Implantable Cardioverter-Defibrillator Recipients Hospitalized with Acute Decompensated Heart Failure

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Abstract

Background

Early risk stratification remains a major challenge in implantable cardioverter-defibrillator (ICD) recipients hospitalized with acute decompensated heart failure with reduced ejection fraction (ADHF-HFrEF). The red cell distribution width-to-albumin ratio (RAR), a composite biomarker integrating inflammatory and nutritional status, has emerged as a promising prognostic marker in cardiovascular disease. However, its prognostic significance in ICD recipients hospitalized with ADHF-HFrEF remains unknown. This study aimed to evaluate the association between admission RAR and in-hospital mortality in this high-risk population.

Methods

This retrospective observational cohort study included 514 consecutive ICD recipients hospitalized with ADHF-HFrEF between January 2022 and March 2025. Admission RAR was calculated by dividing red cell distribution width (%) by serum albumin (g/dL). The primary outcome was all-cause in-hospital mortality. Independent predictors of mortality were identified using multivariable logistic regression analysis, and the discriminative performance of RAR was assessed using receiver operating characteristic (ROC) curve analysis.

Results

Among the 514 patients, 78 (15.2%) died during hospitalization. Admission RAR was significantly higher in non-survivors than in survivors (4.58 ± 1.56 vs. 3.42 ± 0.80 , $p < 0.001$). After multivariable adjustment, age (OR 1.060, 95% CI 1.029–1.091; $p < 0.001$), serum creatinine (OR 1.570, 95% CI 1.205–2.045; $p = 0.001$), serum sodium (OR 0.773, 95% CI 0.718–0.832; $p < 0.001$), C-reactive protein (OR 1.013, 95% CI 1.004–1.021; $p = 0.003$), and RAR > 4.05 (OR 5.812, 95% CI 2.980–11.335; $p < 0.001$) were independently associated with in-hospital mortality. RAR demonstrated good discriminatory performance for predicting in-hospital mortality (AUC 0.813, 95% CI 0.773–0.848; $p < 0.001$).

Conclusion

Admission RAR was independently associated with in-hospital mortality in ICD recipients hospitalized with ADHF-HFrEF. As a simple, inexpensive, and routinely available biomarker, RAR may complement early admission risk stratification in this particularly vulnerable patient population. Prospective multicenter studies are warranted to externally validate these findings.

Introduction

Acute decompensated heart failure with reduced ejection fraction (ADHF-HFrEF) remains one of the leading causes of cardiovascular hospitalization and continues to be associated with substantial short-term mortality despite major advances in guideline-directed medical therapy. Early identification of patients at the highest risk of adverse in-hospital outcomes remains a major unmet clinical need, as it may facilitate timely treatment optimization, appropriate monitoring intensity, and efficient allocation of healthcare resources. Accordingly, several admission-based risk prediction models, including the Acute Decompensated Heart Failure National Registry (ADHERE), the Organized Program to Initiate Lifesaving Treatment in Hospitalized Patients with Heart Failure (OPTIMIZE-HF), and the Emergency Heart Failure Mortality Risk Grade (EHMRG), have been developed to support early prognostic assessment in acute heart failure. However, these models were derived from heterogeneous heart failure populations and may not adequately capture the biological and clinical complexity of specific high-risk subgroups [1–4].

Recipients of implantable cardioverter-defibrillators (ICDs) represent one such clinically distinct subgroup. These patients typically have advanced structural heart disease, severe left ventricular systolic dysfunction, extensive myocardial remodeling, and a high burden of ventricular arrhythmias. Although ICD therapy effectively reduces the risk of sudden arrhythmic death, it does not prevent progressive pump failure, persistent congestion, metabolic derangements, or multi-organ dysfunction, which constitute the principal mechanisms of death during episodes of acute decompensated heart failure. Furthermore, both appropriate and inappropriate ICD therapies have consistently been associated with adverse clinical outcomes, reflecting advanced myocardial disease rather than therapeutic success. Consequently, admission risk stratification strategies established in unselected heart failure populations may not be directly applicable to ICD recipients, highlighting the need for simple, inexpensive, and readily available biomarkers capable of identifying biological vulnerability at the time of hospital admission [5, 6].

The red cell distribution width-to-albumin ratio (RAR) has recently emerged as a promising composite biomarker that integrates two complementary pathophysiological domains closely linked to adverse heart failure outcomes. Elevated red cell distribution width reflects systemic inflammation, oxidative stress, impaired erythropoiesis, and neurohormonal activation, whereas hypoalbuminemia reflects inflammatory burden, congestion-related hepatic dysfunction, endothelial injury, and poor nutritional status. By combining these routinely available laboratory parameters into a single index, RAR may provide a more comprehensive representation of the biological vulnerability accompanying advanced heart failure than either biomarker alone. Consistent with this concept, growing evidence has demonstrated the prognostic value of RAR in chronic heart failure, acute myocardial infarction, transcatheter aortic valve implantation, and other cardiovascular conditions [9–18].

Despite these observations, the prognostic significance of admission RAR has not been investigated in ICD recipients hospitalized with ADHF-HFrEF. Whether this simple biomarker can improve early risk stratification in this particularly vulnerable population therefore remains unknown. We hypothesized that admission RAR reflects biological vulnerability beyond conventional admission laboratory assessment and independently identifies patients at increased risk of in-hospital mortality. Accordingly, the present

study aimed to evaluate the independent prognostic value of admission RAR for predicting in-hospital mortality and to explore its potential role as an early risk stratification tool in ICD recipients hospitalized with ADHF-HFrEF.

Materials and methods

Study design and patient population

This retrospective, single-center observational cohort study enrolled consecutive adult patients with an implantable cardioverter-defibrillator (ICD) who were hospitalized for acute decompensated heart failure with reduced ejection fraction (ADHF-HFrEF) at the Department of Cardiology of a tertiary referral center [institution name blinded for peer review] between January 2022 and March 2025. Patients were identified through the hospital electronic medical record system using International Classification of Diseases, Tenth Revision (ICD-10) heart failure diagnostic codes. The patient selection process is summarized in Fig. 1. After exclusion of patients with missing laboratory data required for RAR calculation or those meeting the predefined exclusion criteria, the final study cohort comprised 514 consecutive patients. In patients with multiple hospitalizations during the study period, only the first admission was included to avoid duplicate observations. ICD implantation had previously been performed for either primary or secondary prevention according to contemporary guideline recommendations.

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki and was approved by the Institutional Ethics Committee of Ankara Etlik City Hospital (Approval No: XXXX; Date: XX/XX/2025). Owing to the retrospective study design and the use of anonymized electronic medical records, the requirement for written informed consent was waived by the ethics committee.

Inclusion and exclusion criteria

Eligible patients fulfilled all of the following predefined inclusion criteria: (1) age ≥ 18 years; (2) previous implantation of an ICD for either primary or secondary prevention according to contemporary guideline recommendations; (3) documented left ventricular ejection fraction (LVEF) $< 40\%$; and (4) hospitalization with a primary diagnosis of acute decompensated heart failure (ADHF). The diagnosis of ADHF was established according to contemporary European Society of Cardiology (ESC) Heart Failure Guidelines and was based on the presence of new-onset or worsening signs and symptoms of heart failure requiring hospital admission and intravenous heart failure therapy. All laboratory measurements used for biomarker calculation were obtained within the first 24 hours after hospital admission [7].

Patients were excluded in the presence of any of the following conditions: unavailable laboratory parameters required for RAR calculation, active infection, systemic inflammatory or autoimmune disease, recent corticosteroid or immunosuppressive therapy, advanced hepatic dysfunction (Child–Pugh class B or C), active malignancy, pregnancy, recurrent hospitalization for acute heart failure

immediately preceding the index admission, or hemodynamic instability requiring inotropic support at presentation (cold hemodynamic profile). To minimize within-patient correlation, only the first hospitalization was included for patients with multiple admissions during the study period.

Clinical, laboratory, and echocardiographic assessment

Baseline demographic characteristics, cardiovascular risk factors, medical history, comorbidities, vital signs, medication use before admission, and duration of hospitalization were retrieved from the institutional electronic medical record system.

Laboratory parameters obtained within the first 24 hours of admission included hemoglobin, white blood cell count, absolute neutrophil count, absolute lymphocyte count, red cell distribution width (RDW), serum albumin, fasting plasma glucose, serum creatinine, sodium, potassium, calcium, chloride, C-reactive protein (CRP), and N-terminal pro-B-type natriuretic peptide (NT-proBNP).

Hypertension was defined as a documented diagnosis according to current medical guidelines. Diabetes mellitus was defined as a documented diagnosis, treatment with glucose-lowering medication, fasting plasma glucose ≥ 126 mg/dL, or glycated hemoglobin (HbA1c) $\geq 6.5\%$. Coronary artery disease, atrial fibrillation, chronic obstructive pulmonary disease, peripheral arterial disease, and other comorbidities were identified from documented medical history, previous diagnostic investigations, and ICD-10 diagnostic codes.

Comprehensive transthoracic echocardiography was performed during the index hospitalization according to current guideline recommendations using commercially available ultrasound systems. Left ventricular ejection fraction was measured using the biplane Simpson method. Echocardiographic examinations were performed by experienced cardiologists who were blinded to clinical outcomes, and measurements were independently verified by a second investigator to minimize observer bias.

Biomarker calculation

The red cell distribution width-to-albumin ratio (RAR) was calculated by dividing red cell distribution width (RDW, %) by serum albumin concentration (g/dL). The neutrophil-to-lymphocyte ratio (NLR) was calculated as the ratio of the absolute neutrophil count to the absolute lymphocyte count. Both biomarkers were derived from laboratory measurements obtained within the first 24 hours after hospital admission. Optimal cutoff values for predicting in-hospital mortality were determined using receiver operating characteristic (ROC) curve analysis based on the maximum Youden index and were identified as > 4.05 for RAR and > 5.32 for NLR.

Study outcome

The primary study endpoint was all-cause in-hospital mortality. Mortality status was determined through review of the institutional electronic medical record system covering the entire index hospitalization. Outcome data were complete for all patients, and no patient was lost to follow-up during hospitalization.

Statistical analysis

Statistical analyses were performed using MedCalc Statistical Software version 20.0 (MedCalc Software Ltd., Ostend, Belgium) and IBM SPSS Statistics version 22.0 (IBM Corp., Armonk, NY, USA). The distribution of continuous variables was assessed using the Kolmogorov–Smirnov test. Continuous variables are presented as mean $\pm$ standard deviation (SD) or median (interquartile range [IQR]), as appropriate, whereas categorical variables are expressed as frequencies and percentages.

Comparisons between survivors and non-survivors were performed using the independent-samples Student's *t* test or the Mann–Whitney *U* test for continuous variables, according to data distribution, and the chi-square test or Fisher's exact test for categorical variables, as appropriate.

Univariable logistic regression analysis was initially performed to identify variables associated with in-hospital mortality. Variables demonstrating statistical significance in univariable analyses ($p < 0.10$), together with clinically relevant covariates, were considered for inclusion in the multivariable logistic regression model. To reduce the risk of model overfitting, only clinically meaningful variables were retained in the final multivariable model. Results are presented as odds ratios (ORs) with corresponding 95% confidence intervals (CIs).

The discriminative performance of RAR and NLR for predicting in-hospital mortality was evaluated using receiver operating characteristic (ROC) curve analysis. Areas under the ROC curves (AUCs) were compared using the DeLong method. Optimal cutoff values were determined according to the maximum Youden index. All statistical tests were two-sided, and a p value < 0.05 was considered statistically significant.

Results

A total of 514 ICD recipients hospitalized with ADHF-HFrEF were included in the final analysis. During the index hospitalization, 78 patients (15.2%) died, whereas 436 (84.8%) survived to hospital discharge. Baseline demographic, clinical, laboratory, and echocardiographic characteristics according to in-hospital mortality are presented in Table 1.

Table 1
Demographic, clinical, laboratory and echocardiographic characteristics according to in-hospital mortality

Variable	Survivors (n = 436)	Non-survivors (n = 78)	p value
Age, years	64.0 ± 20.0	73.0 ± 14.0	< 0.001
Male sex, n (%)	127 (29.1)	23 (29.5)	0.949
Hospitalization duration, days	8.0 ± 8.0	10.0 ± 9.5	0.004
Comorbidities, n (%)			
Diabetes mellitus	144 (33.0)	25 (32.1)	0.866
Hypertension	273 (62.6)	49 (62.8)	0.972
Coronary artery disease	188 (43.1)	19 (24.4)	0.002
Peripheral arterial disease	34 (7.8)	10 (12.8)	0.144
Atrial fibrillation	87 (20.0)	17 (21.8)	0.709
Chronic obstructive pulmonary disease	136 (31.2)	34 (43.6)	0.032
Laboratory findings			
Fasting blood glucose, mg/dL	111.0 ± 58.0	128.0 ± 77.8	< 0.001
Creatinine, mg/dL	1.16 ± 0.98	2.26 ± 1.80	< 0.001
Sodium, mmol/L	138.0 ± 4.8	132.0 ± 4.8	< 0.001
Chloride, mmol/L	101.0 ± 6.0	102.0 ± 4.25	0.309
Calcium, mg/dL	9.0 ± 1.1	8.6 ± 1.0	0.003
Potassium, mmol/L	4.3 ± 0.7	4.6 ± 0.9	< 0.001
Albumin, g/dL	3.8 ± 0.8	3.4 ± 0.9	< 0.001
C-reactive protein, mg/L	19.3 ± 35.5	55.0 ± 30.0	< 0.001
NT-proBNP, ng/mL	2.15 ± 4.87	4.98 ± 18.7	0.001
HDL cholesterol, mg/dL	36.5 ± 14.0	33.4 ± 17.3	0.036
LDL cholesterol, mg/dL	117.9 ± 82.8	120.5 ± 103.8	0.658
Continuous variables are presented as mean ± standard deviation and categorical variables as n (%)			
ACE angiotensin-converting enzyme, HDL high-density lipoprotein, LDL low-density lipoprotein, NT-proBNP N-terminal pro-B-type natriuretic peptide, RAR red cell distribution width-to-albumin ratio, RDW-CV red cell distribution width-coefficient of variation, SGLT2 sodium-glucose co-transporter 2			

Variable	Survivors (n = 436)	Non-survivors (n = 78)	p value
White blood cell count, $\times 10^3/\mu\text{L}$	8.0 ± 3.2	8.6 ± 2.7	0.009
Neutrophil-to-lymphocyte ratio	2.71 ± 2.52	5.13 ± 5.99	< 0.001
Hemoglobin, g/dL	13.6 ± 3.3	12.5 ± 3.9	< 0.001
Platelet count, $\times 10^3/\mu\text{L}$	240.0 ± 103.8	260.0 ± 122.0	0.448
RDW-CV, %	13.0 ± 1.6	15.0 ± 0.8	< 0.001
RAR, %·dL/g	3.42 ± 0.80	4.58 ± 1.56	< 0.001
Echocardiographic findings			
Left ventricular ejection fraction, %	27.0 ± 9.0	28.0 ± 5.0	0.468
Medication at admission, n (%)			
Acetylsalicylic acid	268 (61.5)	49 (62.8)	0.821
Angiotensin receptor blocker	72 (16.5)	19 (24.4)	0.095
ACE inhibitor	338 (77.5)	53 (67.9)	0.068
SGLT2 inhibitor	144 (33.0)	19 (24.4)	0.130
Mineralocorticoid receptor antagonist	313 (71.8)	53 (67.9)	0.490
Statin	208 (47.7)	33 (42.3)	0.379
P2Y12 inhibitor	68 (15.6)	19 (24.4)	0.057
Anticoagulant	234 (53.7)	53 (67.9)	0.019
Continuous variables are presented as mean $\pm$ standard deviation and categorical variables as n (%)			
ACE angiotensin-converting enzyme, HDL high-density lipoprotein, LDL low-density lipoprotein, NT-proBNP N-terminal pro-B-type natriuretic peptide, RAR red cell distribution width-to-albumin ratio, RDW-CV red cell distribution width-coefficient of variation, SGLT2 sodium-glucose co-transporter 2			

Compared with survivors, non-survivors were significantly older (73.0 ± 14.0 vs. 64.0 ± 20.0 years, $p < 0.001$) and had a longer duration of hospitalization (10.0 ± 9.5 vs. 8.0 ± 8.0 days, $p = 0.004$). Chronic obstructive pulmonary disease was more prevalent among non-survivors (43.6% vs. 31.2%, $p = 0.032$), whereas coronary artery disease was less frequent (24.4% vs. 43.1%, $p = 0.002$). No statistically significant differences were observed between the groups with respect to sex, diabetes mellitus, hypertension, atrial fibrillation or peripheral arterial disease. Baseline use of most guideline-directed medical therapies was comparable between the groups, although anticoagulant therapy was more frequent among non-survivors (67.9% vs. 53.7%, $p = 0.019$).

Laboratory findings are summarized in Table 1. Compared with survivors, non-survivors had significantly higher fasting plasma glucose, serum creatinine, potassium, white blood cell count, C-reactive protein, NT-proBNP, RDW, NLR, and RAR values, whereas serum sodium, albumin, calcium, and hemoglobin levels were significantly lower (all $p < 0.05$). Platelet count, chloride, LDL cholesterol, and left ventricular ejection fraction did not differ significantly between the groups. Admission RAR was significantly higher in non-survivors than in survivors (4.58 ± 1.56 vs. 3.42 ± 0.80 , $p < 0.001$).

The results of the logistic regression analyses are presented in Table 2. On univariable analysis, age, chronic obstructive pulmonary disease, fasting plasma glucose, serum creatinine, serum sodium, C-reactive protein, $NLR > 5.32$, and $RAR > 4.05$ were significantly associated with in-hospital mortality. In the multivariable model, age (OR 1.060, 95% CI 1.029–1.091; $p < 0.001$), serum creatinine (OR 1.570, 95% CI 1.205–2.045; $p = 0.001$), serum sodium (OR 0.773, 95% CI 0.718–0.832; $p < 0.001$), C-reactive protein (OR 1.013, 95% CI 1.004–1.021; $p = 0.003$), and $RAR > 4.05$ (OR 5.812, 95% CI 2.980–11.335; $p < 0.001$) remained independently associated with in-hospital mortality, whereas $NLR > 5.32$ was not independently associated with the outcome.

Table 2
Univariable and multivariable logistic regression analysis showing the independent predictors of in-hospital mortality

Variable	Univariable OR (95% CI)	p value	Multivariable OR (95% CI)	p value
Age	1.059 (1.037–1.081)	< 0.001	1.060 (1.029–1.091)	< 0.001
COPD	1.705 (1.043–2.786)	0.033	1.673 (0.847–3.307)	0.139
Creatinine	1.759 (1.419–2.181)	< 0.001	1.570 (1.205–2.045)	0.001
Sodium	0.768 (0.723–0.816)	< 0.001	0.773 (0.718–0.832)	< 0.001
C-reactive protein	1.016 (1.010–1.023)	< 0.001	1.013 (1.004–1.021)	0.003
Fasting blood glucose	1.003 (1.000–1.006)	0.041	—	—
$NLR > 5.32$	4.662 (2.807–7.745)	< 0.001	1.620 (0.823–3.192)	0.163
$RAR > 4.05$	9.179 (5.400–15.606)	< 0.001	5.812 (2.980–11.335)	< 0.001
CI confidence interval, COPD chronic obstructive pulmonary disease, NLR neutrophil-to-lymphocyte ratio, OR odds ratio, RAR red cell distribution width-to-albumin ratio				
Fasting blood glucose was not retained in the final multivariable model				

Receiver operating characteristic (ROC) curve analysis demonstrated good discriminatory performance of RAR for predicting in-hospital mortality (AUC 0.813, 95% CI 0.773–0.848; $p < 0.001$) (Fig. 2). The optimal cutoff value of 4.05 yielded a sensitivity of 78% and a specificity of 74%. For comparison, the AUC of NLR was 0.696 (95% CI 0.650–0.739; $p < 0.001$). Pairwise comparison of the ROC curves using

the DeLong method demonstrated a statistically significant difference between the discriminatory performance of RAR and NLR ($p = 0.003$).

Discussion

The principal finding of the present study is that admission red cell distribution width-to-albumin ratio (RAR) independently predicted in-hospital mortality in implantable cardioverter-defibrillator (ICD) recipients hospitalized with acute decompensated heart failure with reduced ejection fraction (ADHF-HFrEF). This association remained significant after adjustment for established demographic, laboratory, and clinical risk factors, indicating that RAR provides prognostic information beyond conventional predictors of adverse in-hospital outcomes. Furthermore, admission RAR demonstrated good discriminative performance for predicting in-hospital mortality, supporting its potential role as an early risk stratification biomarker in this particularly vulnerable patient population. To our knowledge, this is the first study specifically evaluating the prognostic significance of RAR in ICD recipients hospitalized with ADHF-HFrEF, thereby addressing an important gap in the current literature [8].

The biological plausibility of these findings is supported by the complementary pathophysiological information captured by RAR. Elevated RDW has consistently been associated with chronic systemic inflammation, oxidative stress, impaired erythropoiesis, neurohormonal activation, renal dysfunction, and ineffective red blood cell maturation, all of which contribute to disease progression and poor outcomes in heart failure [9–11, 19]. In contrast, serum albumin reflects multiple systemic processes beyond nutritional status, including inflammatory activity, hepatic synthetic function, endothelial dysfunction, capillary leakage, and congestion-related physiological impairment [12, 13]. Hypoalbuminemia has repeatedly been associated with increased mortality in both acute and chronic heart failure populations [12, 13]. By integrating these two biologically distinct yet complementary markers into a single index, RAR may more comprehensively reflect the overall inflammatory, metabolic, and nutritional burden accompanying advanced heart failure than either parameter alone. This integrated pathophysiological profile may explain why RAR retained independent prognostic significance after multivariable adjustment, whereas NLR lost statistical significance [18].

The clinical importance of RAR may be even greater in ICD recipients than in the general heart failure population. Although ICD therapy substantially reduces the risk of sudden arrhythmic death, it does not modify the progressive pathophysiological mechanisms responsible for worsening heart failure, including persistent ventricular remodeling, progressive pump failure, systemic congestion, neurohormonal activation, and multi-organ dysfunction [5, 6]. Consequently, mortality during episodes of acute decompensation in ICD recipients is increasingly determined by non-arrhythmic mechanisms rather than malignant ventricular arrhythmias. Because RAR reflects the systemic consequences of advanced heart failure rather than arrhythmic risk alone, it may better capture the biological vulnerability that ultimately determines short-term prognosis in this population. This concept is further supported by our finding that RAR remained independently associated with mortality despite adjustment for

conventional clinical and laboratory variables, suggesting that it provides incremental prognostic information beyond established risk markers [5, 6].

Our findings are consistent with and extend the growing body of evidence supporting the prognostic value of RAR across different cardiovascular diseases. Previous studies have demonstrated significant associations between elevated RAR and adverse outcomes in patients with chronic heart failure, non-ischemic heart failure, acute myocardial infarction, transcatheter aortic valve implantation, and broader cardiovascular populations [14–18]. However, these investigations evaluated clinically heterogeneous cohorts in which the underlying mechanisms of mortality differ substantially from those observed in ICD recipients hospitalized with ADHF-HFrEF. The present study expands these observations by demonstrating that RAR also retains independent prognostic value within this highly selected, high-risk subgroup. Importantly, established heart failure risk models such as ADHERE and EHMRG were primarily developed in unselected acute heart failure populations and mainly incorporate hemodynamic parameters, renal function, and natriuretic peptides without considering markers that simultaneously reflect inflammation, nutritional status, and systemic metabolic stress [4]. Our findings therefore suggest that RAR may complement existing admission-based risk assessment strategies by providing additional prognostic information derived from routinely available laboratory parameters [14–18].

The present findings also have important clinical implications. Risk stratification at the time of hospital admission remains a cornerstone of the management of patients with ADHF-HFrEF, particularly among ICD recipients who frequently present with advanced structural heart disease and substantial clinical heterogeneity. Early identification of patients at increased risk for in-hospital mortality may facilitate closer clinical surveillance, more intensive monitoring, timely optimization of guideline-directed medical therapy, and appropriate allocation of healthcare resources. Unlike many established prognostic models that require multiple clinical variables or complex calculations, RAR is derived from two inexpensive and routinely available laboratory parameters obtained at admission, making it readily applicable in everyday clinical practice. Rather than replacing existing risk prediction models, RAR may serve as a complementary biomarker that enhances bedside risk assessment by incorporating information related to systemic inflammation, nutritional status, and metabolic vulnerability—pathophysiological domains that are not adequately represented in traditional heart failure risk scores. Future studies should investigate whether incorporating RAR into established prognostic models improves their predictive performance and clinical utility [1, 8, 18].

The present study possesses several notable strengths. To our knowledge, this is the first investigation specifically evaluating the prognostic significance of RAR in ICD recipients hospitalized with ADHF-HFrEF, thereby addressing an important gap in the literature. The study included a relatively large cohort of consecutive patients treated at a high-volume tertiary referral center, reducing the likelihood of selection bias associated with selective enrollment. Furthermore, all laboratory measurements were obtained within the first 24 hours of hospitalization, reflecting the clinical scenario in which admission-based risk stratification is most relevant. Finally, comprehensive multivariable adjustment was

performed to account for established clinical and laboratory risk factors, supporting the independent prognostic value of RAR in this high-risk population.

Limitations

Several limitations of this study should be acknowledged. First, this was a retrospective, single-center observational study, and therefore residual confounding and limited generalizability cannot be completely excluded despite multivariable adjustment. Second, RAR was calculated only from laboratory measurements obtained at hospital admission; thus, the potential prognostic significance of serial changes in RAR during hospitalization could not be evaluated. Third, detailed device-related characteristics, including ICD therapy burden, ventricular pacing percentage, pacing dependency, and device interrogation data, were unavailable and may have provided additional prognostic information. Finally, external validation was not performed. Therefore, our findings should be interpreted as hypothesis-generating and require confirmation in large prospective multicenter studies before routine clinical implementation.

Conclusion

In conclusion, admission RAR was independently associated with in-hospital mortality in ICD recipients hospitalized with ADHF-HFrEF. As a simple, inexpensive, and readily available biomarker integrating inflammatory and nutritional status, RAR may complement early bedside risk stratification by identifying patients at increased risk of adverse in-hospital outcomes. These findings support the potential clinical utility of admission RAR in this high-risk population and warrant prospective multicenter studies to externally validate its prognostic value and determine its incremental benefit when integrated into established heart failure risk assessment strategies.

Declarations

Conflict of interest

The authors declare that they have no conflict of interest.

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Ethics approval

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Institutional Ethics Committee of Ankara Etlik City Hospital (Approval No: XXXX; Date:

XX/XX/2025).

Consent to participate

The requirement for written informed consent was waived by the ethics committee owing to the retrospective design of the study and the use of anonymized electronic medical records.

Author Contribution

ÇT and RYŞ conceived and designed the study. YÖ, EY, EE, and MTÖ acquired and verified the data. MTÖ performed the statistical analysis, prepared the tables and figures. FB supervised the research and provided critical revision of the manuscript. All authors reviewed and approved the final manuscript.

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Availability of data and materials

The data generated and analyzed during this study are available from the corresponding author upon reasonable request.

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Figures

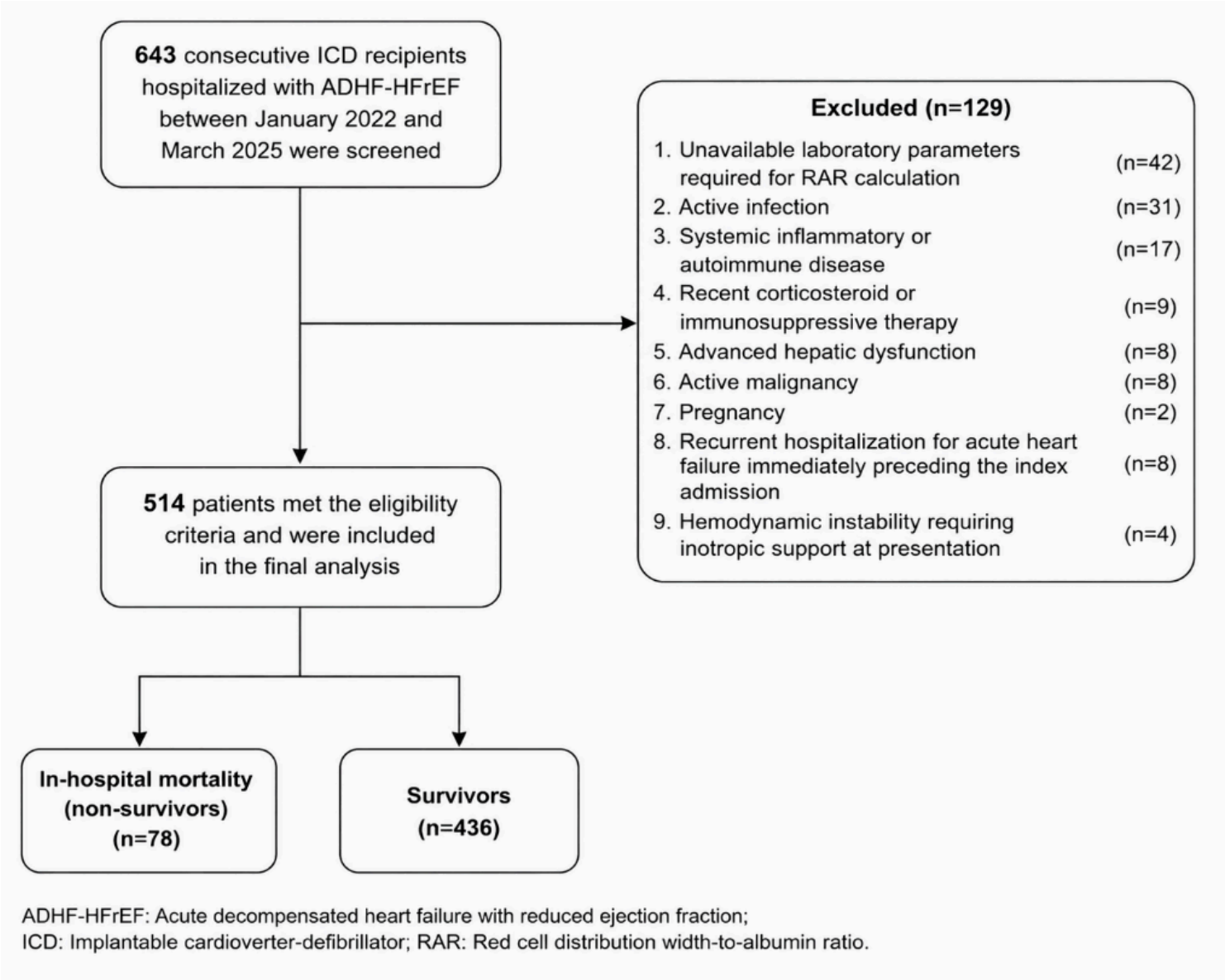


Figure 1

Study flow diagram of patient selection. ADHF-HFrEF acute decompensated heart failure with reduced ejection fraction, ICD implantable cardioverter-defibrillator, RAR red cell distribution width-to-albumin ratio

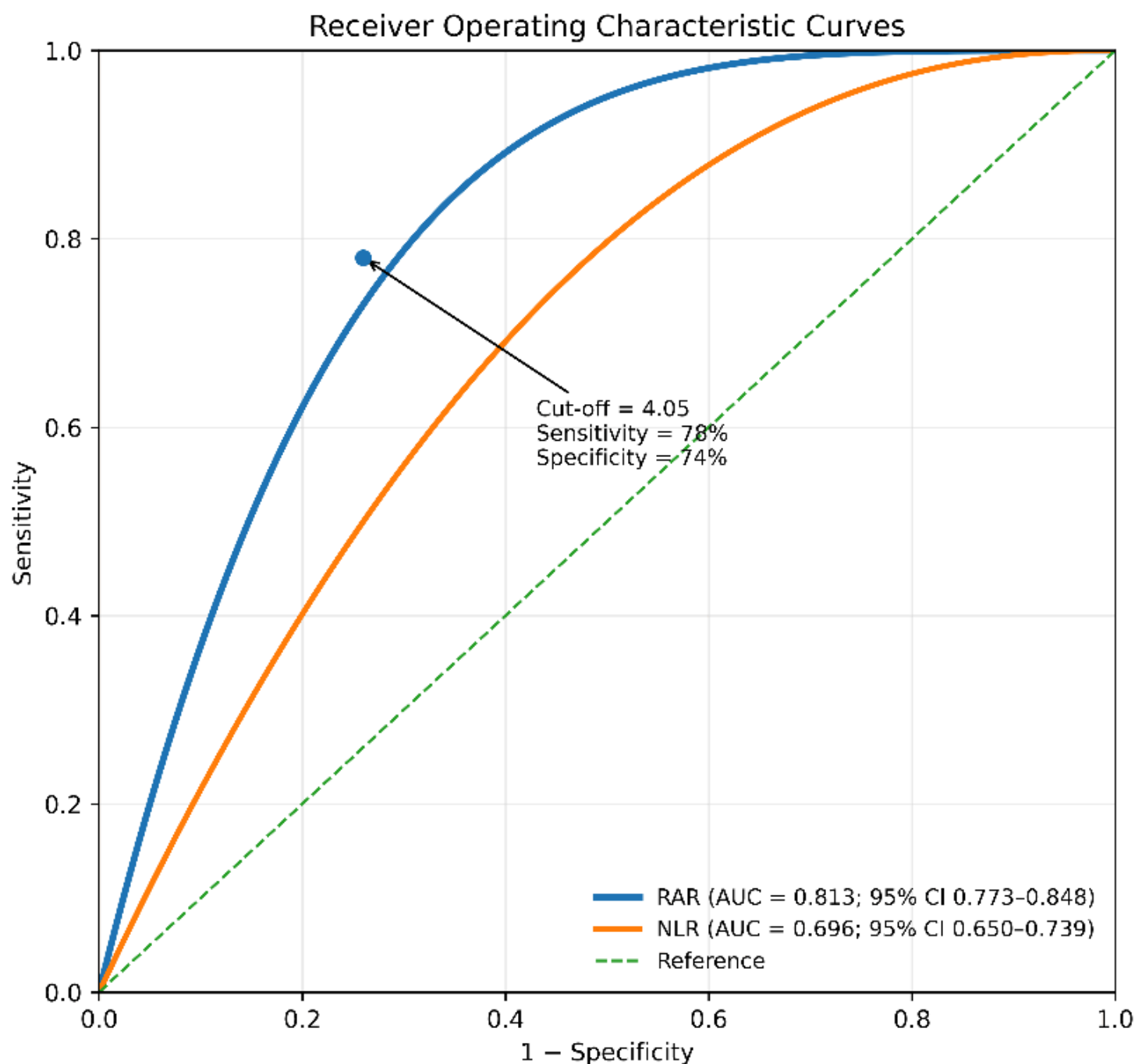


Figure 2

Receiver operating characteristic curves for the red cell distribution width-to-albumin ratio (RAR) and the neutrophil-to-lymphocyte ratio (NLR) in predicting in-hospital mortality. RAR showed superior discrimination compared with NLR (area under the curve 0.813 vs. 0.696; DeLong test $p = 0.003$)

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