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Impact of neutrophil percentage-to-albumin ratio on mortality in iron-deficiency anemia patients: a retrospective study using MIMIC-IV database

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Abstract

Background In the intensive care unit (ICU), the incidence of iron-deficiency anemia (IDA) is relatively high and is associated with various adverse clinical outcomes. Therefore, it is crucial to identify simple and practical indicators to assess the mortality risk in ICU patients with IDA. This study aims to investigate the relationship between the Neutrophil Percentage-to-Albumin Ratio (NPAR) levels in patients with IDA in the ICU and their all-cause mortality at 30 and 365 days.

Materials and methods We analyzed data from the Medical Information Mart for Intensive Care-IV (MIMIC-IV) 3.0 database spanning the years 2008–2022 and identified a cohort of 817 patients with IDA who met our inclusion criteria. Through multivariate Cox regression analysis, the relationship between NPAR levels and 30-day and 365-day mortality risks was assessed, and restricted cubic splines (RCS) models were used to explore potential nonlinear relationships. Additionally, an inflection point analysis was conducted to evaluate the potential of NPAR levels in predicting short- and long-term mortality risks.

Results The study found that high NPAR levels were significantly associated with an increased risk of 30-day and 365-day mortality in patients with IDA (hazard ratio [HR] range 1.49–2.23, $p < 0.001$ for all). The relationship between natural logarithmic transformation (ln) NPAR levels and 30-day and 365-day mortality risks exhibited an inverse "L" shaped pattern. Patient mortality risk increased significantly when ln-transformed NPAR levels exceeded 1.2 (HR range 3.366–4.304, $p < 0.001$ for all). Additionally, subgroup analyses did not reveal any significant interactions, indicating that the predictive effect of NPAR on mortality risk is relatively consistent across different subgroups.

Conclusion We found an inverse "L" shaped relationship between ln-transformed NPAR levels and 30-day and 365-day mortality risks, particularly when ln-transformed NPAR values exceed 1.2, which is significantly associated with an increased risk of death within 30 and 365 days for patients.

Keywords Neutrophil percentage-to-albumin ratio, Iron-deficiency anemia, Intensive care unit, Mortality risk

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Introduction

Iron-deficiency anemia (IDA) is a prevalent global health issue affecting over 1.2 billion people [1]. It exists not only as an independent disease but also can lead to hemodynamic instability, increase surgical risks, and is closely associated with postoperative morbidity and mortality [2]. It is estimated that IDA accounts for about half of the anemia cases worldwide each year and leads to approximately one million deaths [3]. The World Health Organization considers IDA to be one of the most common nutritional deficiencies in the world [4]. Additionally, IDA is also common in a variety of chronic inflammatory diseases, such as congestive heart failure, chronic kidney disease, and inflammatory bowel disease [5]. Therefore, addressing the issue of anemia poses a significant medical, social, and developmental challenge for countries around the world. Most cases of anemia are caused by iron deficiency [6], and improving the nutritional status of vulnerable populations is a key strategy through the fortification of iron or other micronutrients in crops [7].

NPAR is a commonly used indicator to assess an individual's nutritional status and inflammation through a simple and cost-effective method [8]. It is calculated using the same blood sample, based on the formula: Neutrophil percentage (%) × 100/Albumin (g/dl) [9]. The Neutrophil Percentage-to-Albumin Ratio (NPAR) has been significantly associated with the prognosis of various diseases, including pancreatic cancer, stroke-related infections, cardiovascular diseases, and acute kidney injury [8, 10–12]. Although numerous studies have explored the correlation between NPAR and different diseases, there is still a lack of research on the impact of NPAR on the prognosis of IDA patients in the ICU. Furthermore, IDA is also associated with nutritional status and inflammation [13]. Therefore, this study utilizes real-world data to investigate the impact of NPAR on the short-term and long-term mortality rates of IDA patients in the ICU. This research holds significant clinical value for gaining a deeper understanding of the prognosis of IDA patients in the ICU and for guiding clinical decision-making.

Materials and methods

Database introduction

We enrolled 2,808 patients with IDA from the MIMIC-IV database. The MIMIC-IV database consolidates extensive medical information from 65,366 patients admitted to the ICU at Beth Israel Deaconess Medical Center from 2008 to 2022. After the first author, Weide Lin, completed an online review and signed a data usage agreement, database access was granted (authorization number: 62407435). This study adheres to the ethical standards of the Helsinki Declaration, and all patient data in the study were de-identified, waiving the need for informed consent. All reports follow the guidelines for reporting observational studies in epidemiology (STROBE) [14].

Study population

Patients with IDA met the criteria for our study. We excluded patients with missing neutrophil percentage and albumin data, and then excluded patients with a hospital stay and ICU stay of less than 24 h. Ultimately, 817 patients were included. Some patients were admitted to the ICU multiple times, but we only considered those who were admitted to the ICU for the first time.

Covariates and outcome

Patient characteristics previously demonstrated to account for the majority of mortality variation following IDA were assessed. The covariates we extracted from the MIMIC-IV database include: gender, age, race, marital status, heart rate, systolic blood pressure (SBP), diastolic blood pressure (DBP), respiratory (Resp), pulse oximetry derived oxygen saturation (Spo_2), platelet count (PLT), glucose, total bilirubin (TBIL), blood urea nitrogen (BUN), serum creatinine (Scr), prothrombin time (PT), international normalized ratio (INR), activated partial thromboplastin time (APTT), myocardial infarction (MI), peripheral vascular disease (PVD), cerebrovascular disease (CVD), chronic obstructive pulmonary disease (COPD), sepsis, acute kidney injury stage (AKI stage), charlson comorbidity index (CCI), acute physiology score III (APSIII), simplified acute physiology score II (SAPSII), oxford acute severity of illness score (OASIS). Additionally, we categorized NPAR into tertiles, with outcomes being 30-day mortality and 365-day mortality.

Statistical analysis

We used the Shapiro–Wilk test to verify whether the NPAR levels and distribution were normally distributed. Owing to the right-skewed distribution of NPAR levels, we applied a natural logarithmic transformation to achieve a normal distribution. Continuous variables with a normal distribution are depicted as the mean ± standard deviation (SD) and were compared using Student's *t* test or one-way ANOVA. For continuous variables not conforming to a normal distribution, the data are shown as the median and interquartile range (IQR), and the Kruskal–Wallis H test was used for statistical analysis. Categorical variables are expressed as proportions (%) and were tested with a chi-square test or Fisher's exact test. The proportion of missing data for the covariates is relatively low, with the minimum being 0.12% and the maximum being 3.79%, hence no treatment measures were taken.

We used smooth curve fitting and performed both univariate and multivariate Cox regression analyses to

assess the relationship between NPAR levels and the risk of 30-day and 365-day mortality. Extended Cox model methods were applied for different covariate adjustment models. The multivariate model included variables of clinical interest as well as all covariates with statistical significance in the univariate analysis. Additionally, we selected other potential confounders based on previous scientific data or a change in effect estimate exceeding 10%. Our models included: the crude model was unadjusted; Model 1 was adjusted for gender, age, race, Marital status; Model 2 further included SBP, PLT, TBIL, BUN, PT, INR, APTT, MI, CVD, COPD, Sepsis, AKI stage, CCI, APSIII, SAPSII and OASIS in addition to the variables in Model 1; Model 3 further included DBP, Resp, $Spo_{2,}$ glucose, Scr and PVD in addition to the variables in Model 2. Additionally, we conducted threshold effect analysis to assess the potential of NPAR levels in predicting 30-day and 365-day mortality risks.

To ascertain whether the relationship between NPAR levels and the 30-day and 365-day mortality rates is consistent among patients with IDA, we performed interaction and subgroup analyses for gender (male versus female), age (< 65 versus ≥ 65), MI (yes versus no), PVD (yes versus no), CVD (yes versus no), COPD (yes versus no) and Sepsis (yes versus no).

All analyses were performed using the statistical software package R. version 4.4.2 (R Foundation for Statistical Computing, Vienna, Austria) and Free Statistics software version 2.0 p values < 0.05 (two-sided) were considered statistically significant [15].

Results

Study the baseline characteristics of the population

We analyzed data from the MIMIC-IV 3.0 database spanning from 2008 to 2022 and initially identified 2,808 patients with IDA. After excluding 1769 patients with missing neutrophil percentage and albumin data, and 222 patients with hospital stay and ICU stay less than 24 h, a total of 817 participants were included in our analysis. The exclusion criteria flowchart is depicted in Fig. 1.

The baseline demographic and clinical characteristics of the patients are compared in Table 1. The 30-day mortality rate for this cohort was 14.8%, and the 365-day mortality rate was 32.7%. The mean patient age was 63.6 ± 17.1 years, with 50.8% being male and a predominance of Caucasian individuals. Enrolled patients were categorized into three groups based on the quantiles of the NPAR: low group for NPAR < 1.95, medium group for 1.95 ≤ NPAR < 3.64, and high group for NPAR ≥ 3.64. Compared to the low NPAR group, patients in the high NPAR group were more likely to be female, had faster heart and respiratory rates, and exhibited higher values in blood pressure, PLT, glucose, TBIL, BUN, Scr, PT, INR, and severity scores of APACHE III, SAPS II, and OASIS. They also had higher 30-day and 365-day mortality rates, and were more prone to sepsis and AKI.

The correlation between NPAR and all-cause mortality

The univariate analysis of 30-day and 365-day mortality rates in patients with IDA is presented in Table S1. Age, SBP, TBIL, BUN, PT, INR, APTT, MI, Sepsis, AKI stage, CCI, APSIII, SAPSII, OASIS and ln NPAR were risk factors for 30-day mortality ($p < 0.05$); Age, SBP, PLT, TBIL, BUN, PT, INR, APTT, MI, CVD, COPD, sepsis, AKI stage, CCI, APACHE III, SAPS II, OASIS and ln NPAR were risk factors for 365-day mortality ($p < 0.05$). The Kaplan–Meier curves showed a significant correlation between Neutrophil Percentage-to-Albumin Ratio (NPAR) and the risk of 30-day and 365-day mortality (Figure S1).

The results of the multivariate Cox regression analysis examining the relationship between NPAR levels and mortality rates are presented in Table 2. In the unadjusted crude model (HR range 1.49 to 2.23, $p < 0.001$), a significant independent positive correlation was observed between the ln-transformed NPAR and the risk of 30-day and 365-day mortality; this correlation was also evident in the fully adjusted Model 3 (HR range 1.58 to 2.23, $p < 0.001$). When NPAR was treated as a categorical variable, higher levels of NPAR (NPAR ≥ 3.64) were associated with increased 30-day and 365-day mortality risks (crude model, HR range of 1.64 to 2.79, $p < 0.01$). According to the fully adjusted Model 3, patients with higher NPAR levels (NPAR ≥ 3.64) had a 2.32-fold increased risk of 30-day mortality and a 68% increased risk of 365-day mortality compared to the low NPAR group (NPAR < 1.95) (Model 3, HR range of 1.68 to 2.32, $p < 0.01$). Additionally, in the RCS model, the association between the ln-transformed NPAR levels and 30-day and 365-day mortality risks both exhibited an inverse L-shaped curve (non-linear, $p < 0.001$) (Fig. 2). In the threshold analysis, when the ln-transformed NPAR levels were less than 1.2, there was no association between NPAR levels and the 30-day and 365-day mortality risks in patients (HR range 0.981 to 1.173, $p > 0.05$) (Table 3). When the ln-transformed NPAR level was ≥ 1.2, the 30-day and 365-day mortality risks in patients significantly increased (HR range from 3.366 to 4.304, $p < 0.001$, Table 3), which means that for each unit increase in the ln-transformed NPAR, the 30-day mortality risk increased by 4.304 times, and the 365-day mortality risk increased by 3.366 times.

Subgroup analysis

To determine whether the relationship between ln-transformed NPAR levels and the 30-day and 365-day

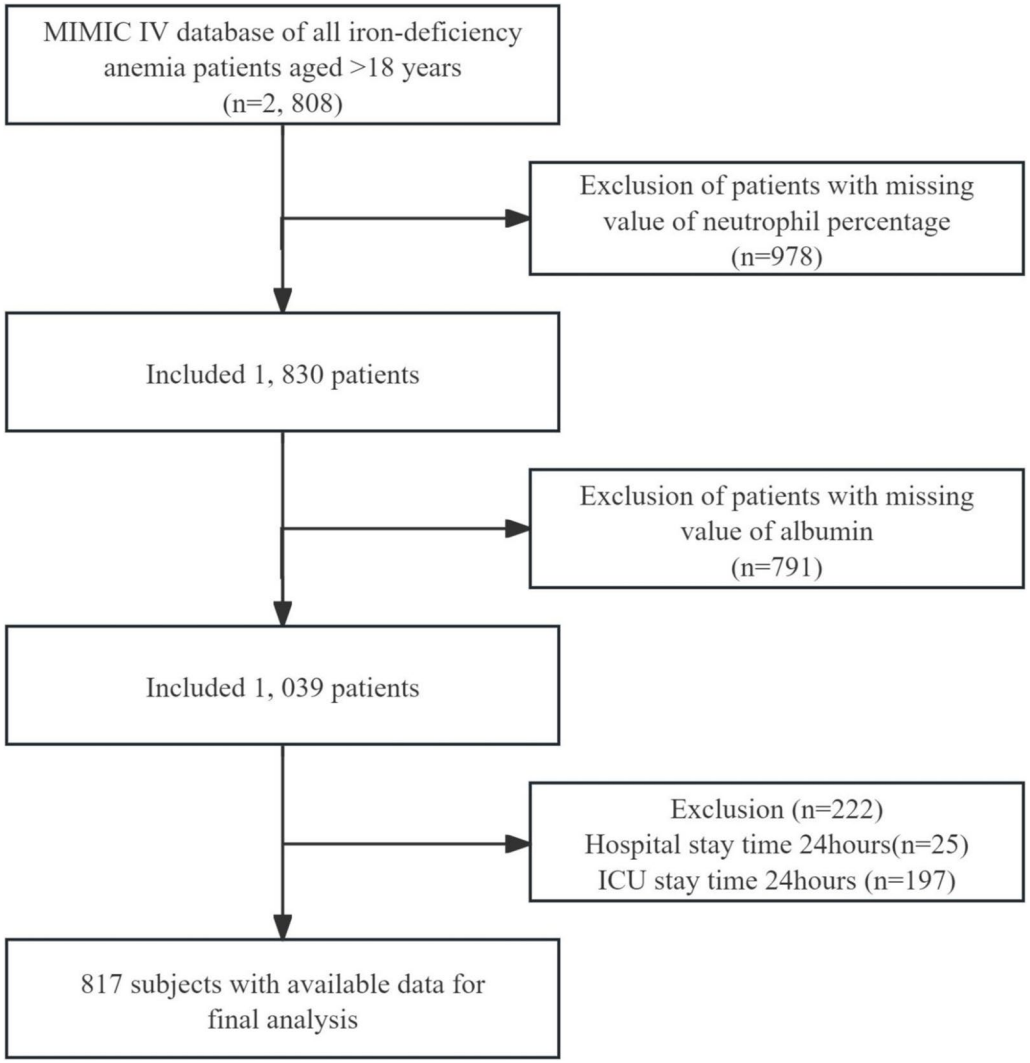

Fig. 1 Schematic representation of the participant selection process and distribution of participant groups. This schematic illustrates the process of participant selection and the distribution across different participant groups. The flowchart detailed the inclusion and exclusion criteria, ultimately showing that 817 subjects had available data for final analysis

mortality rates in patients with IDA exists across different subgroups, we conducted stratified and interaction analyses by age, gender, MI, PVD, CVD, COPD, and sepsis. No statistically significant interactions were found among the subgroups (Figure S2).

Discussion

Our study reveals a close association between NPAR levels and the risk of mortality in patients with IDA, emphasizing the increased risk when NPAR levels exceed a specific threshold. Additionally, we have explored the nonlinear relationship between NPAR and the risk of death, providing new perspectives for future research.

IDA is common among critically ill patients treated in the ICU and can lead to severe consequences [16]. The etiology of anemia in ICU patients is often the result of multiple factors interacting, which may include the patient's pre-existing chronic diseases, such as chronic kidney disease, cardiovascular diseases, and COPD, all of which can independently lead to anemia. Additionally, patients in the ICU may undergo frequent diagnostic tests and therapeutic procedures, such as central venous catheter insertion and surgical operations, which can result in additional blood loss. Concurrently, critically ill patients may experience hemolysis due to infection, inflammation, or other reasons, further exacerbating anemia [17]. Therefore, predicting

Table 1 Baseline characteristics of participants

Variables	Total ($n=817$)	NPAR < 1.95 ($n=272$)	1.95 ≤ NPAR < 3.64 ($n=272$)	NPAR ≥ 3.64 ($n=273$)	*p* value
Gender, *n* (%)					0.025
Female	402 (49.2)	119 (43.8)	132 (48.5)	151 (55.3)	
Male	415 (50.8)	153 (56.2)	140 (51.5)	122 (44.7)	
Age (years)	63.6 ± 17.1	64.3 ± 17.0	63.3 ± 17.7	63.1 ± 16.8	0.683
Race/ethnicity, *n* (%)					0.165
White	479 (58.6)	152 (55.9)	158 (58.1)	169 (61.9)	
Black	123 (15.1)	52 (19.1)	35 (12.9)	36 (13.2)	
Other	215 (26.3)	68 (25)	79 (29)	68 (24.9)	
Marital status, *n* (%)					0.827
Married	307 (37.6)	109 (40.1)	96 (35.3)	102 (37.4)	
Single	256 (31.3)	81 (29.8)	90 (33.1)	85 (31.1)	
Other	158 (19.3)	55 (20.2)	53 (19.5)	50 (18.3)	
NA*	96 (11.8)	27 (9.9)	33 (12.1)	36 (13.2)	
Heart rate (bpm)	106.7 ± 21.9	101.6 ± 21.1	107.2 ± 21.6	111.4 ± 22.0	< 0.001
SBP (mmHg)	147.7 ± 24.6	150.7 ± 24.3	147.8 ± 24.2	144.5 ± 24.9	0.013
DBP (mmHg)	91.2 ± 20.7	94.0 ± 21.7	92.5 ± 20.8	87.3 ± 19.1	< 0.001
Resp (bpm)	29.2 ± 6.8	27.9 ± 6.0	29.7 ± 6.6	30.1 ± 7.5	< 0.001
Spo_2 (%)	99.6 ± 0.9	99.6 ± 1.0	99.5 ± 1.0	99.6 ± 0.8	0.49
PLT($\times 10^9$/L)	233.0 (166.0, 314.0)	208.0 (144.0, 266.2)	242.5 (189.0, 326.8)	253.0 (171.0, 348.0)	< 0.001
Glucose (mg/dL)	149.0 (117.0, 205.0)	137.5 (110.8, 188.2)	150.0 (123.0, 208.5)	158.0 (121.0, 217.0)	0.002
TBIL (μmol/L)	0.6 (0.4, 1.3)	0.6 (0.4, 1.2)	0.6 (0.4, 1.2)	0.7 (0.4, 1.7)	0.007
BUN (mg/dL)	27.0 (15.0, 47.0)	24.0 (15.0, 40.0)	27.0 (15.0, 46.2)	32.0 (17.0, 53.0)	0.009
Scr (mg/dL)	1.3 (0.9, 2.1)	1.2 (0.9, 1.9)	1.2 (0.8, 2.1)	1.4 (1.0, 2.3)	0.019
PT (s)	15.0 (13.1, 18.7)	14.1 (12.7, 17.8)	14.5 (12.8, 18.1)	16.2 (13.9, 20.9)	< 0.001
INR (s)	1.4 (1.2, 1.7)	1.3 (1.2, 1.6)	1.3 (1.2, 1.7)	1.5 (1.3, 1.9)	< 0.001
APTT (s)	32.5 (28.2, 43.6)	32.2 (28.4, 40.6)	31.6 (27.9, 41.1)	33.5 (28.2, 48.7)	0.229
MI, *n* (%)					0.354
No	668 (81.8)	225 (82.7)	215 (79)	228 (83.5)	
Yes	149 (18.2)	47 (17.3)	57 (21)	45 (16.5)	
PVD, *n* (%)					0.945
No	734 (89.8)	243 (89.3)	245 (90.1)	246 (90.1)	
Yes	83 (10.2)	29 (10.7)	27 (9.9)	27 (9.9)	
CVD, *n* (%)					0.129
No	721 (88.2)	239 (87.9)	233 (85.7)	249 (91.2)	
Yes	96 (11.8)	33 (12.1)	39 (14.3)	24 (8.8)	
COPD, *n* (%)					0.335
No	604 (73.9)	208 (76.5)	193 (71)	203 (74.4)	
Yes	213 (26.1)	64 (23.5)	79 (29)	70 (25.6)	
Sepsis, *n* (%)					< 0.001
No	308 (37.7)	128 (47.1)	115 (42.3)	65 (23.8)	
Yes	509 (62.3)	144 (52.9)	157 (57.7)	208 (76.2)	
AKI stage					0.002
0	526 (64.4)	201 (73.9)	173 (63.6)	152 (55.7)	
1	191 (23.4)	48 (17.6)	67 (24.6)	76 (27.8)	
2	35 (4.3)	6 (2.2)	12 (4.4)	17 (6.2)	
3	65 (8.0)	17 (6.2)	20 (7.4)	28 (10.3)	
CCI	5.0 (3.0, 8.0)	6.0 (3.0, 8.0)	5.0 (3.0, 8.0)	5.0 (3.0, 8.0)	0.427
APSIII	49.2 ± 19.2	43.5 ± 17.8	47.2 ± 17.9	56.8 ± 19.3	< 0.001
SAPSII	37.9 ± 14.0	34.7 ± 12.6	37.2 ± 13.2	41.9 ± 15.2	< 0.001

Table 1 (continued)

Variables	Total ($n=817$)	NPAR < 1.95 ($n=272$)	1.95 ≤ NPAR < 3.64 ($n=272$)	NPAR ≥ 3.64 ($n=273$)	*p* value
OASIS	32.5 ± 8.4	30.5 ± 8.3	32.7 ± 7.9	34.4 ± 8.6	< 0.001
30-day mortality, *n* (%)					< 0.001
No	696 (85.2)	246 (90.4)	243 (89.3)	207 (75.8)	
Yes	121 (14.8)	26 (9.6)	29 (10.7)	66 (24.2)	
365-day mortality, *n* (%)					0.001
No	550 (67.3)	193 (71)	196 (72.1)	161 (59)	
Yes	267 (32.7)	79 (29)	76 (27.9)	112 (41)	

Continuous variables are presented as mean ± SD or median (quartile), while categorical variables are presented as absolute numbers (percentages)

*NA** missing values, *SBP* systolic blood pressure, *DBP* diastolic blood pressure, *Resp* respiratory, Spo_2 pulse oximetry derived oxygen saturation, *PLT* Platelet Count, *TBIL* total bilirubin, *BUN* blood urea nitrogen, *Scr* serum creatinine, *PT* prothrombin time, *INR* international normalized ratio, *APTT* activated partial thromboplastin time, *MI* myocardial infarction, *PVD* peripheral vascular disease, *CVD* cerebrovascular disease, *COPD* chronic obstructive pulmonary disease, *AKI stage* acute kidney injury stage, *CCI* charlson comorbidity index, *APSIII* acute physiology score III, *SAPSII* simplified acute physiology score II, *OASIS* oxford acute severity of illness score

Table 2 Relationships between NPAR, 30-day mortality, and and 365-day mortality in different models

Variable	Crude model		Model I		Model II		Model III	
	HR (95% CI)	*p*-value	HR (95% CI)	*p*-value	HR (95% CI)	*p*-value	HR (95% CI)	*p*-value
30-day mortality								
NPAR as continuous	2.23 (1.74–2.86)	< 0.001	2.26 (1.77–2.89)	< 0.001	2.22 (1.63–3.03)	< 0.001	2.23 (1.62–3.07)	< 0.001
NPAR < 1.95	Ref		Ref		Ref		Ref	
1.95 ≤ NPAR < 3.64	1.14 (0.67–1.93)	0.638	1.13 (0.66–1.92)	0.658	1.05 (0.59–1.86)	0.873	0.97 (0.54–1.74)	0.921
NPAR ≥ 3.64	2.79 (1.77–4.39)	< 0.001	2.92 (1.84–4.64)	< 0.001	2.32 (1.36–3.96)	0.002	2.32 (1.34–4.02)	0.003
P for trend		< 0.001		< 0.001		0.001		0.001
365-day mortality								
NPAR as continuous	1.49 (1.25–1.77)	< 0.001	1.61 (1.35–1.92)	0.012	1.55 (1.26–1.92)	< 0.001	1.58 (1.28–1.96)	< 0.001
NPAR < 1.95	Ref		Ref		Ref		Ref	
1.95 ≤ NPAR < 3.64	0.97 (0.7–1.32)	0.825	1.01 (0.74–1.39)	0.954	0.95 (0.68–1.34)	0.776	0.94 (0.66–1.33)	0.732
NPAR ≥ 3.64	1.64 (1.23–2.19)	0.001	1.88 (1.4–2.52)	< 0.001	1.58 (1.13–2.23)	0.008	1.68 (1.18–2.38)	0.004
P for trend		0.001		< 0.001		0.006		0.003

Crude model was not adjusted

Model 1 was adjusted for gender + age + race + Marital status

Model 2 was adjusted for model 1 + SBP + PLT + TBIL + BUN + PT + INR + APTT + MI + CVD + COPD + Sepsis + AKI stage + CCI + APSIII + SAPSII + OASIS

Model 3 was adjusted for model 2 + DBP + Resp + Spo_2 + glucose + Scr + PVD

SBP systolic blood pressure, *PLT* Platelet Count, *TBIL* total bilirubin, *BUN* blood urea nitrogen, *PT* prothrombin time, *INR* international normalized ratio, *APTT* activated partial thromboplastin time, *MI* myocardial infarction, *CVD* cerebrovascular disease, *COPD* chronic obstructive pulmonary disease, *AKI stage* acute kidney injury stage, *CCI* charlson comorbidity index, *APSIII* acute physiology score III, *SAPSII* simplified acute physiology score II, *OASIS* oxford acute severity of illness score, *DBP* diastolic blood pressure, *Resp* respiratory, Spo_2 pulse oximetry derived oxygen saturation, *Scr* serum creatinine, *PVD* peripheral vascular disease

the mortality risk of IDA patients in the ICU in advance can help improve prognosis.

Neutrophils are an economical and widely used method to assess the presence of inflammation, playing a key role in the inflammatory response. When inflammation occurs, neutrophils can quickly be attracted to the site of infection, producing reactive oxygen species and chemokines that damage the vascular endothelium [18–20]. Albumin is an important indicator of nutritional status [21], and its low levels often predict poor prognosis, which may be related to malnutrition in patients or the presence of inflammation in the body [22].The NPAR is recognized as an inflammation-based prognostic predictor [23], and has the advantages of being cost-effective and easily accessible [24]. A substantial amount of research has shown that NPAR levels are a valuable clinical indicator and have been proven to be closely associated with the risk of mortality in patients with diseases across various systems, including the circulatory, respiratory, nervous, urinary, endocrine, and musculoskeletal systems [25–29]. Previous studies have shown that IDA is associated with a chronic inflammatory state, which in turn is linked to poor prognosis [30–32]. Additionally, IDA anemia is closely related to a patient's nutritional

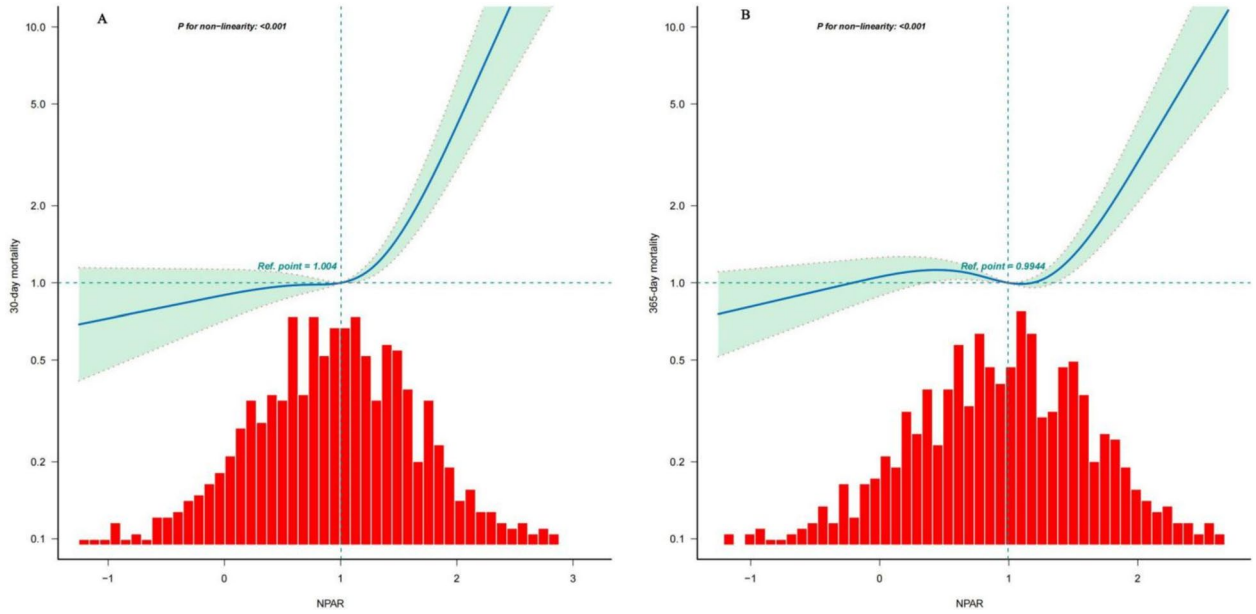

Fig. 2 **A** Nonlinear dose–response relationship between ln-transformed NPAR and 30-day mortality. **A** The nonlinear dose–response relationship between ln-transformed NPAR and 30-day mortality is presented. Adjustments were made for gender, age, race, Marital status, heart rate, SBP, DBP, Resp, Spo_2, PLT, glucose, TBIL, BUN, Scr, PT, INR, APTT, MI, PVD, CVD, COPD, Sepsis, AKI stage, CCI, APSIII, SAPSII, OASIS. The blue line indicates the estimated mortality risk, while the green area represents the 95% confidence interval. Data for 99% of participants is displayed. **B** Nonlinear dose–response relationship between ln-transformed NPAR and 365-day mortality. **B** This figure shows the nonlinear relationship between ln-transformed NPAR and 365-day mortality, with adjustments for the same factors as in **A**. The estimated values and 95% confidence intervals are depicted similarly, providing insights into how NPAR influences 365-day mortality risks

Table 3 Threshold effect analysis of NPAR levels on 30-day mortality and and 365-day mortality

30-day mortality				365-day mortality			
Threshold of driving pressure	**HR**	**95%CI**	***p*-value**	**Threshold of driving pressure**	**HR**	**95%CI**	***p*-value**
NPAR < 1.2	1.173	0.588, 2.342	0.6503	NPAR < 1.2	0.981	0.696, 1.383	0.912
NPAR ≥ 1.2	4.304	2.17, 8.536	< 0.001	NPAR ≥ 1.2	3.366	2.008,5.643	< 0.001
Likelihood Ratio test			0.02	Likelihood Ratio test			< 0.001

HR hazard ratio, *CI* confidence interval. Both adjustment factors included gender, age, race, Marital status, heart rate, SBP, DBP, Resp, Spo_2, PLT, glucose, TBIL, Bun, Scr, PT, INR, APTT, MI, PVD, CVD, COPD, Sepsis, AKI stage, CCI, APSIII, SAPSII, OASIS

status, and the quality of nutritional status also affects patient outcomes [33, 34]. Our research results emphasize the significance of NPAR levels in the prognostic assessment of patients with IDA. Conducting personalized and timely risk assessments for patients with IDA can help to devise more precise treatment plans and improve outcomes. Compared to complex clinical scoring systems, NPAR, as an easily usable prognostic biomarker, can be directly obtained from routine blood tests; therefore, it is an effective tool for rapid risk assessment. Medical professionals can use the NPAR levels at admission to stratify patient risk. For those patients with IDA who have higher NPAR values, clinicians should pay more attention.

When interpreting our study results, some limitations must be taken into account. First, due to the retrospective nature of our study, there may be selection bias and information bias. Second, our study population was limited to patients within the MIMIC-IV database, which may restrict the generalizability of our findings. Future studies should employ a prospective design and consider these potential confounding factors to further validate our observations.

Conclusion

Despite these limitations, our study offers valuable insights, showing that ln-transformed NPAR levels have a nonlinear relationship with the 30-day and 365-day

mortality risks of IDA patients in the ICU, with higher NPAR values associated with increased 30-day and 365-day mortality, especially when ln-transformed NPAR exceeds 1.2, and the risk increases significantly.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s40001-024-02268-7.

Supplementary Material 1. Figure S1. Kaplan-Meier survival analysis of NPAR and 30-day mortality in patients with iron-deficiency anemia. A: Kaplan-Meier survival analysis depicting the association between NPAR and 30-day mortality among patients who underwent iron-deficiency Anemia. The survival curves are stratified by NPAR status, highlighting the differences in survival probabilities. B: Kaplan-Meier survival analysis of NPAR and 365-day mortality in patients with iron-deficiency anemia. B: This Kaplan-Meier survival plot examines the relationship between NPAR and 365-day mortality in patients with iron-deficiency Anemia. Indicating the impact of NPAR on 365-day mortality rates.

Supplementary Material 2. Figure S2. Subgroup analysis of the association between ln-transformed NPAR and 30-day mortality and 365-day mortality. Subgroup analysis assessed the association between ln-transformed NPAR and 30-day mortality as well as 365-day mortality. This analysis explored the impact of ln-transformed NPAR on mortality across different subgroups, including factors such as age, gender, and comorbidities, to determine its consistency.

Supplementary Material 3.

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Author contributions
Weide Lin, Junfan Chen, Xufa Peng, Yaohua Yu, Shiqing Huang, Shurong Li and Bixia Lin had full access to all of the data and take responsibility for the content of the manuscript,including the data and analysis. Concept and design: Weide Lin, Bixia Lin, Yaohua Yu, Shiqing Huang, Shurong Li Acquisition, analysis, or interpretation of data: Weide Lin, Junfan Chen, Xufa Peng. Drafting of the manuscript: Weide Lin. Critical revision of the manuscript for important intellectual content: Weide Lin, Bixia Lin. Statistical analysis: Weide Lin. Administrative, technical, or material support: Bixia Lin.

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Availability of data and materials
All the datasets utilized in the current study are freely accessible in the MIMIC-IV v3.0 database (https://mimic.physionet.org/).

Declarations

Ethics approval and consent to participate
Beth Israel Deaconess Medical Center and the Institutional Review Board of MIT have both approved the establishment of the MIMIC-IV database. This study adheres to the ethical standards of the Helsinki Declaration. All patient data in the study have been de-identified, which meets the criteria for exemption from ethical review, thereby waiving the need for informed consent. All reports follow the guidelines for reporting observational studies in epidemiology.

Competing interests
The authors declare no competing interests.

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