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ORIGINAL ARTICLE

The correlation between the hemoglobin-to-red cell distribution width ratio and all-cause mortality in patients with malignant tumors and sepsis: A retrospective cohort study using the MIMIC-IV database

Shu Zhang[1], Shan Xu[2] (✉), Rui Liao[1], Kaixiu Qin[2]

[1] Department of Hepatological Surgery, The First Affiliated Hospital of Chongqing Medical University, Chongqing 400013, China
[2] Department of Emergency, The Second Affiliated Hospital of Chongqing Medical University, Chongqing 400010, China

Abstract

Objective The aim of the study was to investigate the correlation between the hemoglobin-to-red cell distribution width ratio (HRR) and all-cause mortality in patients with malignant tumors and sepsis.

Methods All patients who met the inclusion criteria of the Medical Information Mart for Intensive Care (MIMIC)-IV were selected and divided into four groups according to the quartile range of HRR distribution. Kaplan-Meier (K-M) analysis was used to plot the 28-day survival curve, and the log-rank test was used to compare the prognosis in each HRR group. A Cox proportional hazards regression model was used to evaluate the prognosis of HRR as both a continuous and categorical variable, and a restricted cubic spline was used to study the effect of HRR, as a continuous variable, on the mortality in patients with malignant tumors and sepsis. Interaction and subgroup analyses were performed to evaluate the consistency of correlations.

Results A total of 3926 patients were included in the study, including 934 patients in the HRR ≤ 4.97 group, 988 patients in the 4.97 < HRR ≤ 6.26 group, 1005 patients in the 6.26 < HRR ≤ 7.84 group, and 999 patients in the HRR ≥ 7.84 group. According to the K-M analysis, the 28-day survival rate was the lowest in the HRR ≤ 4.97 group (59.53%), and there were significant differences in survival rates among different HRR levels ($P < 0.001$). The Cox proportional hazards regression model found that after adjusting for various potential confounding factors, HRR was negatively correlated with 28-day and 365-day mortality, and the risk of death in the HRR ≥ 7.84 group was significantly lower than that in the HRR ≤ 4.97 group ($P = 0.030$ and $P = 0.008$, respectively). The restricted cubic spline plot revealed a linear and negative relationship between the HRR and the 28-day and 365-day mortality rates. Subgroup analysis revealed an interaction between HRR, blood urea nitrogen, and SAPS II scores ($P = 0.010$ and $P = 0.048$, respectively).

Conclusion Low HRR is an independent risk factor for all-cause mortality in patients with malignant tumors and sepsis and could be used as a prognostic indicator for these patients.

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Key words: Hemoglobin-to-red cell distribution width ratio (HRR); malignant tumors; sepsis; prognosis; the Medical Information Mart for Intensive Care (MIMIC)-IV

Over the past 30 years, substantial progress has been made in the prevention, diagnosis, and treatment of various types of malignant tumors, leading to improved survival rates in patients with malignancy [1, 2]. However, significant improvements in the care of patients with malignant tumors are often accompanied by an increased risk of life-threatening complications such as severe infections caused by surgery or immunotherapy, which have become major non-malignant causes of death [3–5]. Moreover, the specific involvement of malignant tumors

✉ Correspondence to: Shan Xu. Email: 601421954@qq.com

may directly alter the host defense against pathogens, leading to severe infections [6]. Sepsis is one of the leading causes of patients with cancer being admitted to the intensive care unit (ICU) [7]. It has been reported that the risk of sepsis is ten times higher in patients with cancer than in hospitalized non-cancer patients [8]. Moreover, the in-hospital mortality rate of patients with malignancy and sepsis exceeds 25%, which is significantly higher than that of non-malignant patients with sepsis [9, 10], especially in younger patients with malignancy [11, 12]. The treatment of critically ill patients with malignant tumors and sepsis is extremely challenging; thus, it is necessary to identify simple and sensitive clinical variables to predict the risk of death in these patients and provide a theoretical basis for personalized treatment.

Hemoglobin (Hb) and red blood cell distribution width (RDW) are markers derived from red blood cells and also are routine indicators in the complete blood cell count, which can reflect the nutritional, oxidative stress, and inflammatory status of the body [13–16]. As Hb and RDW are mutually influenced by each other, recent studies from various fields suggest that the ratio of Hb to RDW [Hb/RDW ratio (HRR)] could be used as a novel parameter to investigate its relationship with these diseases [17–19]. In particular, the predictive value of the HRR for the prognosis in patients with malignancy has been widely recognized [20–23]. Recent studies have shown that a decrease in HRR is also an independent predictor of an increased risk of all-cause mortality associated with sepsis, atrial fibrillation, and sepsis-related encephalopathy [24, 25]. Both malignant tumors and sepsis share many pathological and physiological features and are caused by the dysregulated host immune response to the initial injury, such as the transformation of malignant tumor cells and invasion of pathogens into the tissue, suggesting the possible existence of mutual effects [8, 26]. However, to date, no studies have been published on the use of a combined HRR index to evaluate the prognosis in patients with malignant tumors and sepsis.

This retrospective study aimed to investigate the correlation between HRR at admission and the prognosis in patients with malignancy and sepsis. A low HRR at ICU admission was shown to be associated with an increased mortality risk. In patients with malignant tumors and sepsis, the HRR could serve as a valuable indicator for predicting prognosis.

Methods

Data source

All relevant data in this study were obtained from the the Medical Information Mart for Intensive Care (MIMIC) (MIMIC-IV version 2.0) database [27]. The MIMIC-IV version 2.0 was updated on June 22, 2022, with additional death records after patient discharge, which can better facilitate the study of long-term prognosis in critically ill patients. The researchers accessed and extracted the data from the database after completing relevant training courses provided by the National Institutes of Health (NIH) in the United States and obtaining certification (Certification Number: 36743986).

Study population and diagnostic criteria

The study population included patients who met MIMIC-IV database criteria. The inclusion criteria were as follows: (1) patients with malignant tumors complicated by sepsis, with malignant tumors determined based on ICD-9 (140-208) or ICD-10 (C00-C96) codes; and (2) diagnosis of sepsis made according to the Sepsis-3.0 definition published jointly by the Society of Critical Care Medicine (SCCM) and the European Society of Intensive Care Medicine (ESICM) in 2016, which requires the presence of a new infection and a new organ dysfunction (SOFA score > 2) [28]. In this study, patients with a record of antibiotic use and a SOFA score > 2 were considered to have sepsis. The exclusion criteria were as follows: (1) age < 18 years, (2) ICU stay < 1 d, and (3) lack of HRR records within 24-hours of ICU admission. The HRR was calculated as follows: HRR = Hb (g/L) / RDW (%). Only the data from the first admission of patients with multiple admissions were included in the analysis.

Outcome variables

The main outcome variable was 28-day mortality, and the secondary outcome variables included ICU stay, hospital stay, ICU mortality, hospital mortality, and 365-day mortality.

Data extraction

All data were extracted using structured query language (SQL), including demographic data (age, sex, weight), laboratory test results (renal function, coagulation function, electrolytes), comorbidities [hypertension, diabetes, chronic obstructive pulmonary diseases (COPD), chronic heart failure], severity scores (SAPS II, SOFA), and prognosis (ICU mortality, hospital mortality, 28-day mortality, and 365-day mortality). Laboratory test results with > 5% missing values were excluded, and missing values were imputed with the mean or median.

Statistical analysis

All data were analyzed using STATA 16.0. Continuous variables were expressed as mean ± standard deviation ($\chi \pm s$) or median (interquartile range) [M (IQR)] based on their distribution and analyzed using one-way ANOVA or Kruskal-Wallis tests. Categorical variables were expressed as percentages and analyzed using the chi-square test. This study plotted the 28-day K-M curve of patients

with malignant tumors and sepsis at different HRR levels and performed a log-rank test. Cox proportional hazards regression models were used to determine the adjusted hazard ratios (HRs) and 95% confidence interval (CI) for 28-day and 365-day mortality, with HRR as a continuous and categorical variable, and a restricted cubic spline was used to evaluate the effect of HRR as a continuous variable on mortality in patients with malignancy and sepsis. Subgroup analyses were performed to eliminate the confounding factors. A P-value < 0.05 was considered statistically significant.

Results

Baseline characteristics of different HRR groups

Following a stepwise screening process, 3926 patients were included in the analysis after excluding those with duplicate hospitalizations, non-sepsis, non-malignant tumors, and ICU length of stay of less than 24 hours. The screening process is illustrated in Fig. 1. Based on the quartile distribution of HRR at ICU admission, patients were divided into four groups: HRR ≤ 4.97 group (n = 934), 4.97 < HRR ≤ 6.26 group (n = 988), 6.26 < HRR ≤ 7.84 group (n = 1005), and HRR ≥ 7.84 group (n = 999). The general characteristics, laboratory test results, vital signs, comorbidities, disease severity scores, and prognoses of the four groups are shown in Table 1. There were more male patients in the high-HRR group. In terms of laboratory indicators, as HRR increased, Hb, white blood cell (WBC) count, and platelet (PLT) count increased, whereas RDW decreased. Blood urea nitrogen (BUN) and creatinine levels were higher and prothrombin time (PT), activated partial thromboplastin time (APTT), and international normalized ratio (INR) were longer in the low HRR group. Serum potassium and calcium levels were lower in the low-HRR group. Additionally, patients in the low HRR group were more likely to have underlying comorbidities, such as hypertension and diabetes; had higher CCI, SOFA, and SAPS II scores; and had a higher continuous renal replacement therapy (CRRT) proportion during hospitalization (P < 0.05). However, there was no statistical difference among the four groups in terms of age, serum sodium and chloride levels, vital signs at admission, or invasive mechanical ventilation proportion.

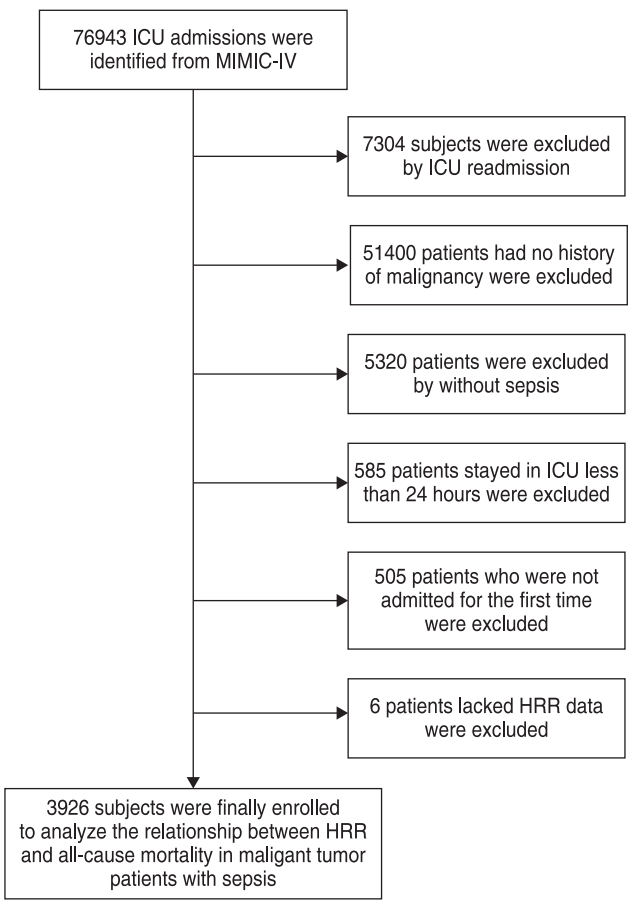

Fig. 1 Flow chart

Prognosis in different HRR groups

In this study, the K-M curve of 28-day mortality was plotted to investigate the prognostic differences among the different HRR groups. The results showed that patients in the different HRR groups had significantly different prognoses. The group with HRR ≤ 4.97 had the lowest 28-day survival rate of 59.53% (556/934), and the survival rate gradually increased with increasing HRR. The survival rates of 4.97 < HRR ≤ 6.26 group, 6.26 < HRR ≤ 7.84 group, and HRR ≥ 7.84 group were 63.46% (627/988), 68.65% (690/1005), and 79.18% (791/999), respectively. The log-rank test indicated that the differences among the four groups were statistically significant (P < 0.001; Fig. 2).

The primary outcomes of this study are summarized in Table 2. There were no significant differences in the length of ICU stay between the groups. The low HRR group had a longer hospital stay and higher ICU, in-hospital, 28-day, and 365-day mortality rates. Moreover, the mortality rates decreased gradually with increasing HRR, and the differences among the four groups were statistically significant (P < 0.05).

The relationship between HRR and mortality in patients with malignant tumors and sepsis

A Cox proportional hazards regression model was used to determine the relationship between HRR level and 28-day and 365-day mortality in patients with malignant tumors and sepsis. Model I was not adjusted for any parameters; Model II was adjusted for sex and age only; and Model III was adjusted for potential confounding

Table 1 Demographic characteristics of study population in each group

Variables	HRR ≤ 4.97 (*n* = 934)	4.97 < HRR ≤ 6.26 (*n* = 988)	6.26 < HRR ≤ 7.84 (*n* = 1005)	HRR ≥ 7.84 (*n* = 999)	H/F/χ^2-value	*P*-value
Demographic						
Age (year)	68.2 ± 13.1	69.4 ± 13.2	70.0 ± 12.5	68.1 ± 13.5	6.812	0.078
Male [*n* (%)]	538 (57.6)	563 (57.0)	611 (60.8)	680 (68.1)	32.198	< 0.001
Weight (kg)	77.8 ± 22.1	78.4 ± 21.7	78.2 ± 20.4	81.3 ± 21.8	7.612	0.055
Laboratory indexes						
Hb (g/dL)	7.7 ± 1.2	9.3 ± 1.1	10.6 ± 1.1	12.9 ± 1.5	121.164	< 0.001
WBC (× 10^{12}/L)	9.8 (5.1–16.9)	11.0 (6.4–17.0)	10.9 (7.1–16.1)	11.9 (8.2–16.2)	29.423	< 0.001
PLT (× 10^9/L)	141 (62–245)	187 (107–296)	201 (129–305)	207 (150–275)	159.580	< 0.001
RDW (%)	19.2 ± 2.9	16.8 ± 2.1	15.3 ± 1.6	13.9 ± 1.2	865.188	< 0.001
Creatine (mg/dL)	1.2 (0.8–2.0)	1.1 (0.7–1.8)	1.0 (0.7–1.6)	1.0 (0.7–1.3)	46.398	< 0.001
BUN (mg/dL)	28 (18–46)	24 (16–41)	22 (15–35)	19 (14–27)	152.044	< 0.001
PT (S)	15.7 (13.6–18.7)	14.9 (13.3–17.8)	14.3 (12.8–16.8)	13.4 (12.1–15.2)	237.138	< 0.001
APTT (S)	31.5 (27.8–39.0)	31.3 (27.4–37.7)	30.6 (26.7–37.2)	29.6 (26.1–34.2)	56.197	< 0.001
INR	1.4 (1.2–1.7)	1.3 (1.2–1.6)	1.3 (1.1–1.5)	1.2 (1.1–1.4)	238.756	< 0.001
Serum potassium (mmol/L)	4.3 ± 0.9	4.3 ± 0.9	4.3 ± 0.8	4.3 ± 0.9	10.234	0.017
Serum sodium (mmol/L)	137.3 ± 5.7	137.1 ± 5.6	137.3 ± 5.7	137.6 ± 6.0	5.012	0.171
Serum chlorine (mmol/L)	102.8 ± 6.9	102.3 ± 7.0	102.3 ± 6.8	101.8 ± 6.8	0.833	0.841
Serum calcium (mg/dL)	8.1 ± 1.0	8.3 ± 1.1	8.4 ± 1.0	8.6 ± 0.9	32.410	< 0.001
Glucose (mg/dL)	125.0 (103.0–162.0)	127.0 (103.0–164.0)	130.5 (105.0–167.0)	135.0 (111.0–168.0)	28.440	< 0.001
Serum anion gap (mmol/L)	16.2 ± 5.0	15.7 ± 4.9	15.5 ± 4.4	16.1 ± 4.7	16.765	< 0.001
Bicarbonate (μmol/L)	22 (18–25)	23 (19–26)	23 (20–26)	23 (21–26)	75.878	< 0.001
Vital signs						
HR (BPM)	97.9 ± 21.0	97.1 ± 21.9	94.7 ± 20.9	93.1 ± 21.8	3.613	0.306
RR (BPM)	21.6 ± 6.9	21.1 ± 6.6	20.3 ± 6.7	20.2 ± 6.6	2.450	0.484
T (°C)	36.8 ± 0.8	36.8 ± 0.8	36.8 ± 0.9	36.8 ± 0.9	2.518	0.472
MBP (mmHg)	76 (66–87)	78 (67–90)	80 (70–91)	84 (73–97)	12.798	0.005
SpO_2 (%)	98 (95–100)	98 (95–100)	98 (94–100)	97 (95–100)	0.604	0.896
Complication						
COPD [*n* (%)]	74 (7.9)	58 (5.9)	79 (7.9)	43 (4.3)	14.801	0.002
Chronic heart failure [*n* (%)]	86 (9.2)	75 (7.6)	69 (6.9)	48 (4.8)	14.749	0.002
Diabetes [*n* (%)]	283 (30.3)	291 (29.5)	274 (27.3)	238 (23.8)	12.267	0.007
Hypertension [*n* (%)]	336 (36.0)	375 (38.0)	421 (41.9)	445 (44.5)	18.050	< 0.001
HIV [*n* (%)]	15 (1.6)	15 (1.5)	15 (1.5)	20 (2.0)	1.029	0.794
CCI	9 (7–11)	9 (7–11)	9 (7–11)	8 (6–10)	88.791	< 0.001
Severity score						
SAPS II	47 (39–57)	45 (37–56)	44 (35–54)	41 (32–50)	114.215	< 0.001
SOFA	7 (5–10)	6 (4–9)	6 (4–8)	5 (3–7)	148.832	< 0.001
Organ support [*n* (%)]						
CRRT	66 (7.1)	42 (4.3)	44 (4.4)	26 (2.6)	22.687	< 0.001
mechanical ventilation	349 (37.4)	423 (42.8)	455 (45.3)	483 (48.4)	25.316	< 0.001
vasoactive agent	468 (50.1)	460 (46.6)	493 (49.1)	394 (39.4)	27.448	< 0.001

Note: WBC: white blood cell; PLT: platelet; BUN: blood urea nitrogen; PT: prothrombin time; APTT: activated partial thromboplastin time; INR: international normalized ratio; HR: heart rate; RR: respiratory rate; MBP: mean blood pressure; COPD: chronic obstructive pulmonary diseases; CCI: chronic disease index; CRRT: continuous renal replacement therapy

factors such as age, weight, sex, Hb, PLT, WBC, creatinine, INR, PT, anion gap, bicarbonate, SAPS II, and SOFA. The results showed that higher HRR was associated with a lower risk of death [HR (95% CI): 0.7 (0.6–0.8), P < 0.001], and the difference was statistically significant (P < 0.001) after adjusting for potential confounding factors in Model III. As a categorical variable, it was also found that compared with the HRR ≤ 4.97 group, the HRR ≥ 7.84 group had a significantly reduced risk of death [HR (95% CI): 0.6 (0.4–1.0)], and the difference was statistically significant (P = 0.030). The 365-day mortality rates were also similar (Table 3).

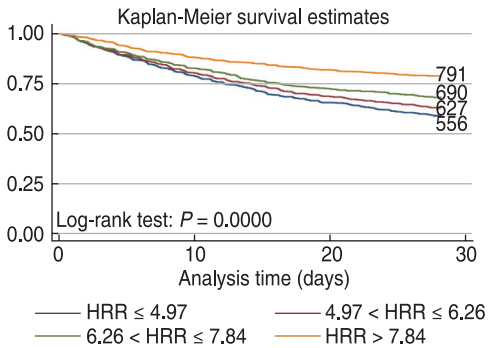

Fig. 2 Kaplan-Meier survival curves of 28-day mortality classified into four groups according to HRR level

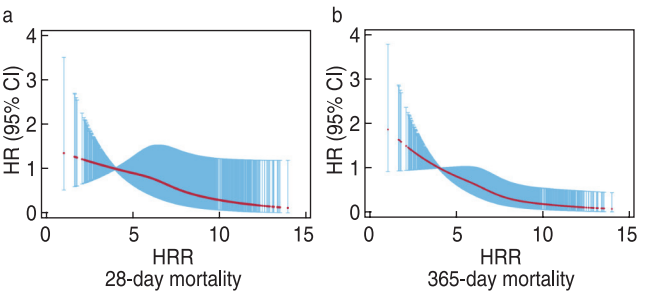

Fig. 3 Restricted cubic splines of the relationship between HRR and mortality in malignancy-associated sepsis patients. (a) HRR and 28-day mortality; (b) HRR and 365-day mortality

Table 2 Comparison of outcomes among different HRR groups

Variables	HRR ≤ 4.97 (*n* = 934)	4.97 < HRR ≤ 6.26 (*n* = 988)	6.26 < HRR ≤ 7.84 (*n* = 1005)	HRR ≥ 7.84 (*n* = 999)	Statistical value	*P*-value
ICU los (d)	3.0 (1.9–5.8)	3.1 (1.8–5.7)	3.0 (1.9–5.4)	3.1 (1.8–6.3)	1.551	0.670
Hospital los (d)	10.12 (5.8–20.0)	9.7 (5.7–17.1)	9.3 (5.6–15.9)	9.1 (5.8–14.9)	13.953	0.003
ICU-mortality [*n* (%)]	209 (22.4)	194 (19.6)	168 (16.7)	122 (12.2)	37.962	< 0.001
In hospital-mortality [*n* (%)]	329 (35.2)	308 (31.2)	253 (25.1)	171 (17.1)	91.940	< 0.001
28 d-mortality [*n* (%)]	378 (40.5)	361 (36.5)	315 (31.3)	208 (20.8)	97.458	< 0.001
365 d-mortality [*n* (%)]	697 (74.6)	677 (68.5)	587 (58.4)	448 (44.8)	209.314	< 0.001

Table 3 Correlation analysis of HRR and its grouping with mortality in patients with malignant tumor and sepsis in different Cox regression models

	Model-I		Modle-II		Modle-III	
	HR (95% CI)	*P* value	HR (95% CI)	*P* value	HR (95% CI)	*P* value
28 d-mortality						
HRR	0.9 (0.8–0.9)	< 0.001	0.9 (0.8–0.9)	< 0.001	0.7 (0.6–0.8)	< 0.001
HRR ≤ 4.97	1		1		1	
4.97 < HRR ≤ 6.26	0.9 (0.8–1.0)	0.093	0.9 (0.8–1.0)	0.066	1.1 (0.9–1.3)	0.585
6.26 < HRR ≤ 7.84	0.7 (0.6–0.9)	< 0.001	0.7 (0.6–0.8)	< 0.001	0.9 (0.7–1.3)	0.714
HRR ≥ 7.84	0.5 (0.4–0.5)	< 0.001	0.5 (0.4–0.5)	< 0.001	0.6 (0.4–1.0)	0.030
365 d-mortality						
HRR	0.9 (0.8–0.9)	< 0.001	0.9 (0.8-0.9)	< 0.001	0.7 (0.6–0.8)	< 0.001
HRR ≤ 4.97	1		1		1	
4.97 < HRR ≤ 6.26	0.9 (0.8–1.0)	0.004	0.8 (0.8–0.9)	0.002	1.1 (0.9–1.2)	0.472
6.26 < HRR ≤ 7.84	0.7 (0.6–0.7)	< 0.001	0.7 (0.6–0.7)	< 0.001	0.9 (0.7–1.1)	0.280
HRR ≥ 7.84	0.4 (0.4–0.5)	< 0.001	0.4 (0.4–0.5)	< 0.001	0.7 (0.5–0.9)	0.008

Note: Model I: no other parameter adjustments were made; Model II: adjusted for gender and age; Model III: adjusted for age, gender, hemoglobin, platelets, white blood cells, creatinine, blood urea nitrogen, prothrombin time, international normalized ratio, activated partial thromboplastin time, anion gap, bicarbonate, potassium, sodium, hypertension, chronic obstructive pulmonary disease, diabetes mellitus, chronic heart failure, chronic respiratory failure, SAPS II, SOFA, and initial vital signs at admission

Relationship between HRR as a continuous variable and the mortality of patients with malignant tumors and sepsis

This study investigated the relationship between HRR as a continuous variable and mortality in patients with malignant tumors and sepsis using restricted cubic splines. The results showed that HRR had a linear and negative correlation with 28-day and 365-day mortality in patients with malignant tumors and sepsis. Specifically, a higher HRR was associated with lower mortality risk in these patients (Fig. 3).

Subgroup analysis

To further investigate the relationship between HRR and mortality in patients with malignant tumors and sepsis, a subgroup analysis was conducted. The results showed that there was an interaction between HRR and BUN, as well as the SAPS II score (P = 0.010, and P = 0.048; Fig. 4).

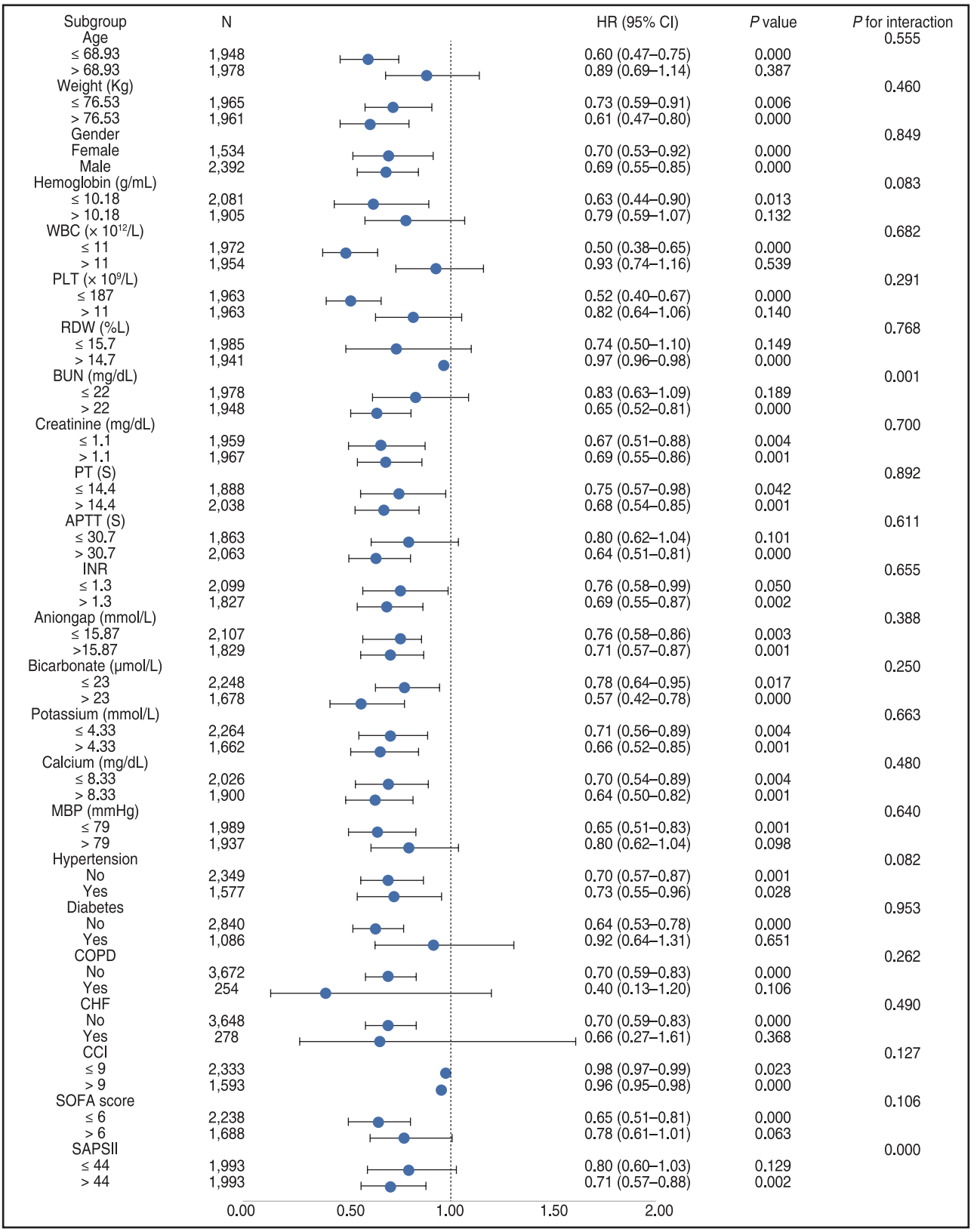

Fig. 4 Subgroup analysis

Discussion

A total of 3926 patients from the MIMIC-IV database were included in this study. The results showed that among patients with malignant tumors and sepsis, the 28-day mortality rate was 33.01% (1262/3926) and the 365-day mortality rate was as high as 61.36% (2409/3926), consistent with other studies [29, 30]. The HRR at ICU admission is related to the prognosis in patients with malignant tumors and sepsis. As HRR levels increase, the length of hospital stay, 28-day mortality, and 365-day mortality of patients with malignant tumors and sepsis decrease. Multivariate Cox proportional hazards regression analysis showed that after adjusting for potential confounding factors, a lower HRR was an independent risk factor for 28-day mortality and 365-mortality ($P < 0.05$). As a categorical variable, it indicated that compared to patients with lower HRR levels (HRR ≤ 4.97 group), those with higher HRR levels (HRR ≥ 7.84 group) had a significantly lower risk of mortality.

The HRR has emerged as a novel comprehensive biomarker for predicting overall and disease-free survival in patients with malignant tumors [20]. A low HRR is closely associated with a poor prognosis in small cell lung cancer [31], and a similar result has been reported in studies on non-small cell lung cancer [32]. As a simple, easy-to-obtain, and reproducible hematological parameter, HRR can also be used for the prognosis in patients with lung large-cell neuroendocrine carcinoma [33]. Additionally, HRR levels have shown good predictive value for survival among patients with gastric cancer treated with neoadjuvant [23]. Su *et al* found that HRR levels were associated with disease progression and poor prognosis in upper tract urothelial carcinoma [21], and the combination of HRR and platelet-lymphocyte ratio could predict the prognosis in patients with liver metastases from gastric cancer. Recent studies have found that the HRR has excellent predictive value for the prognosis in patients with sepsis [34]. A study using the MIMIC-IV database found that a low HRR was associated with increased all-cause mortality among patients with sepsis. Another MIMIC database study found that low HRR levels were associated with poor prognosis in patients with sepsis-associated encephalopathy [25]. This study confirmed that a low HRR at ICU admission was associated with an increased risk of mortality. The HRR can be used to assess the severity and prognosis in patients with malignant tumors and sepsis.

The HRR is a valuable indicator, obtained by calculating the Hb/RDW ratio, that can effectively predict the prognosis in patients with malignant tumors and sepsis. Low Hb levels are usually associated with malnutrition and decreased immune response. Low hematocrit and anemia are independent risk factors for poor prognosis in sepsis [35, 36]. RDW is an essential parameter of complete blood count, representing the variability in red blood cell counts, and has been widely studied in patients with sepsis. A series of studies have confirmed that elevated RDW is closely related to the poor prognosis of sepsis [37–40]. However, while the HRR can be used to predict the prognosis in patients with malignant tumors and sepsis, it is not simply a combination of Hb and RDW, as these two factors may influence each other in the following ways: first, malnutrition usually results in low levels of Hb in patients with malignant tumors, and the body undergoes an inflammatory response and oxidative stress after suffering from sepsis. As a result, both the number of red blood cells and the Hb level decrease [41, 42]. The reduction in Hb shortens the lifespan of red blood cells, releases a large number of immature red blood cells into the circulation, and leads to an increase in RDW. Second, cytokine production induced by oxidative stress in patients with sepsis can reduce erythrocyte survival time and increase RDW [43]. In summary, the HRR reflects changes in both Hb and RDW simultaneously and can provide more predictive information than a single indicator.

In this study, an interaction between HRR and blood urea nitrogen was observed. A low HRR was closely associated with a higher risk of mortality in patients with BUN levels > 22 mg/dL. This is consistent with a study by Huang *et al*, which found that in patients with septic encephalopathy who had a history of dialysis, a low HRR was strongly associated with a high mortality risk [25]. This study also found an interaction between the HRR and SAPS II scores.

This study has several limitations. First, as it was a retrospective study, unavoidable bias may have affected the authenticity of the research results. Second, owing to the lack of data in public databases, some information, such as blood gas analysis, was missing. Third, only a single HRR level at ICU admission was selected to evaluate its relationship with the prognosis in patients with malignant tumors and sepsis. Since the impact of dynamic changes on the outcome was unable to be assessed, dynamic monitoring during hospitalization may be more valuable for prognostic prediction in patients with malignant tumors and sepsis.

Conclusion

In summary, early clinical diagnosis and appropriate interventions are crucial. The HRR is an effective predictor of prognosis in patients with malignant tumors and sepsis. Thus, a decrease in HRR could indicate a poor prognosis in patients with malignant tumors and sepsis. These results should be validated in prospective clinical studies.

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Conflicts of interest
The authors indicated no potential conflicts of interest.

Author contributions
Shu Zhang contributed to the statistical analysis and manuscript writing. Shan Xu contributed to data acquisition and interpretation. Rui Liao and Kaixiu Qin reviewed and approved the final manuscript.

Data availability statement
The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Ethical approval
Not applicable.

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