

Original Article

Mortality predictors on the day of healthcare-associated *Acinetobacter baumannii* bacteremia in intensive care unit

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Abstract

Introduction: Mortality of healthcare-associated *Acinetobacter baumannii* bacteremia can be 50-60% in intensive care units (ICUs). We aimed to determine the risk factors for 28-day mortality in patients with sepsis due to *A. baumannii* bacteremia during their ICU follow-up.

Methodology: Demographic characteristics, disease severity scores on admission and bacteremia day (BD), resistance status, invasive interventions, and laboratory values showing the infection and severity of the BD, were compared between groups with and without mortality as a retrospective cohort study in the ICU of a tertiary hospital.

Results: Of a total of 2411 patients, there were 192 cases of bacteremia. After applying the exclusion criteria, 39 patients were recruited for the study, 25 of whom died (mortality rate 64.1%). Higher age, Simplified Acute Physiology Score II (SAPS II) on admission and high Sequential Organ Failure Assessment Score (SOFA), Red Blood Cell Distribution Width (RDW) ($p < 0.001$), and C-Reactive Protein (CRP) ($p = 0.002$) on the BD and invasive intervention in follow-up were associated with mortality. When CRP and RDW were both positive, sensitivity was 72%, specificity was 100%, negative predictive value was 33%, and positive predictive value was 100% for the 28-day mortality after BD. Based on multivariate analysis, CRP and RDW values on the BD were independent risk factors for mortality.

Conclusions: It is critical to monitor SOFA, RDW, and CRP values in older ICU patients with SAPS II scores and who undergo invasive intervention in follow-up. Increases in these parameters may indicate bacteremia with high mortality due to *A. baumannii*.

Key words: *Acinetobacter*; bacteremia; mortality; intensive care unit.

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Introduction

Healthcare-associated infections (HAI) due to resistant microorganisms in intensive care units (ICU) emerge as an important consequence of antibiotic use during follow-up and treatment. These infections have increased due to the widespread use of invasive interventions and immunosuppressive treatments [1]. Among HAIs, blood-borne infections (BBIs) following bacteremia can lead to sepsis, septic shock, and multi-organ failure, resulting in increased morbidity and mortality. Bacteremia caused by *A. baumannii* is frequently seen in intensive care units (ICUs) and is often multi-drug resistant (MDR), leading to 50-60% morbidity and mortality rates [2,3]. Therefore *A. baumannii* bacteremia and related infection risk factors should be investigated, and, if possible, eliminated or

minimized to reduce the high mortality associated with BBI. Close follow-up of patients in terms of infection, initiation of appropriate empirical antibiotic therapy for the possible agent, taking cultures just before the treatment, and treatment change according to the results are critical [2,4].

Several studies have determined the risk factors for mortality due to *A. baumannii* bacteremia [5-7], however, to our knowledge, there is no published literature investigating the correlation of clinical and laboratory data on the occurrence of *A. baumannii* bacteremia that occurred after ICU admission with the mortality of patients. Previous studies have evaluated the patients only on ICU admission. In our study, patients were examined for *A. baumannii* bacteremia during ICU follow-up. We evaluated the clinical and

laboratory findings both on the day of admission to the ICU and on the day *A. baumannii* bacteremia was detected (BD), including the sub-parameters of the hemogram that we use in daily practice, especially in inflammatory conditions. In this study, we aimed to determine the risk factors for 28-day mortality after the diagnosis of bacteremia and to develop a new perspective for early diagnosis and treatment.

Methodology

Patient population

In this retrospective cohort study, patients that were admitted to the 16-bed general ICU at the tertiary level Kütahya Health Sciences University Faculty of Medicine Evliya Çelebi Training and Research Hospital between January 2014-March 2020 were evaluated.

After applying exclusion criteria, we divided the remaining patients into two groups, those who died and those who did not die within 28 days from BD.

The inclusion criteria were as follows: (a) no growth in blood cultures taken in the hospital ward before admission to the ICU, (b) *A. baumannii* growth in at least one blood culture taken after 48 h of follow-up in the ICU, (c) diagnosed as having healthcare-associated *A. baumannii* bacteremia together with clinical sign and symptom of systemic infection, and (d) age ≥ 18 yrs.

The exclusion criteria were as follows: (a) patients hospitalized in the ICU for less than 48 hours (b) *A. baumannii* bacteremia not associated with healthcare, (c) evaluation of the isolate detected in the blood culture as contamination because clinical and laboratory findings do not demonstrate any infection, (d) polymicrobial presence of bacteremia, (e) second detection of *A. baumannii* bacteremia, (f) Pregnancy, malignancy, and immunosuppressive therapy.

Intensive care specialists decided to take blood cultures from the patients; cultures were taken with methods and indications in line with the standard guidelines [8]. Indications for blood culture were: (1) suspicion of clinical bacteremia or fungemia in the presence of at least two criteria of systemic inflammatory response syndrome (SIRS), (2) prediagnosis of clinical endocarditis, (3) prediagnosis of sepsis when the patient is evaluated according to current sepsis guidelines [4,8,9].

The presence of \geq two SIRS criteria and *A. baumannii* growth in the blood culture, the infection status of the patient was accepted as *A. baumannii* bacteremia [10]. Positive blood cultures were evaluated with ICU clinical microbiologists, and infectious

disease specialists, and the given empirical antibiotic therapy was revised when necessary.

Microbiological evaluation

Blood cultures were inoculated into vials that contained BD BACTEC™ Standard Aerobic Medium (Becton Dickinson, Sparks, MD, USA). Blood culture vials were incubated in the BD BACTEC FX40 Blood Culture System. Identification and antibiotic susceptibility of microorganisms grown in vials with growth signal were performed using BD PHOENIX M50 Medium (Becton Dickinson, Sparks, MD, USA). Colistin resistance was confirmed with the liquid microdilution method. Antibiotic susceptibility results were interpreted according to the European Committee for Antimicrobial Susceptibility Testing (EUCAST) guidelines and breakpoint tables for interpretation of minimum inhibitory concentration (MIC) and zone diameters (Version 12.0, 2022) [11]. There was no change in the laboratory method used during the study period.

Descriptions

HAI was defined as the absence of any BBI at the time of admission to the hospital and the infection developing 48 hours after admission to the ICU. The European Centre for Disease Prevention and Control criteria were used for diagnosis [12].

A. baumannii BD was defined as the day the blood culture exhibited bacterial growth for the first time.

Strains were considered multidrug-resistant (MDR) when there was bacterial resistance to ≥ 3 antibiotic groups [13]. In the presence of resistance to antibiotics other than colistin and tigecycline, the strains were accepted as extensively drug-resistant (XDR) [14].

Death within 28 days from the BD and in the presence of at least one of the following was considered *A. baumannii*-associated patient death, that is, death attributable to this agent. These were (a) presence of blood culture *A. baumannii* positivity on the day of death, (b) death before signs and symptoms of *A. baumannii* bacteremia and/or sepsis disappeared, and (c) absence of any non-infectious cause of death [6].

Appropriate empirical treatment was defined as an effective and appropriate dose of antibiotic therapy to *A. baumannii* grown in blood cultures, which was started at least 72 h before the BD and continued within 72 h of the BD [6].

Data collection

Demographic data, clinical and laboratory values, microbiologic growth, antibiotic treatments, hospital

and ICU lengths of stay, and mortality status of the patients were obtained from patient files, infection control committee surveillance, and the hospital database. The data were recorded in previously created case report forms.

In addition, Simplified Acute Physiology Scores (SAPS II) on the day of admission, Pitt bacteremia score on the BD [15], Sequential Organ Failure Assessment (SOFA) scores, *A. baumannii* resistance patterns, appropriate empirical antibiotic use, invasive interventions on the BD, and the presence of septic shock on the BD and after bacteremia was evaluated according to the current definition of sepsis [4].

We examined inflammatory laboratory parameters on BD because they increase with systemic acute inflammation, show the severity of the infection, and can be a predictor of mortality. In particular, the sub-parameters of the hemogram were examined in detail. C-reactive protein (CRP), albumin, glucose, neutrophil/albumin, neutrophil percentage (%)/albumin, and neutrophil/lymphocyte and thrombocyte/lymphocyte ratios were recorded.

Statistical Analysis

The Statistical Package for the Social Sciences (IBM SPSS) Statistics for Windows, Version 20 (IBM Corp. Armonk, NY, USA) program was used for statistical analysis. The independent samples t-test was used for variables that met the assumption of normal distribution, and mean and standard deviation values were given. The Mann-Whitney U test was used for variables in which the assumption of normal distribution was not met, and median, first and third quartile values (25-75%) were given. The Chi square test was used to compare categorical variables.

Receiver operating characteristics (ROC) curves were plotted, and cut-off points were determined to detect the probability of variables to predict mortality. According to the univariate and ROC analysis results, logistic regression analysis was performed to investigate independent risk factors for 28-day mortality. The Hosmer and Lemeshow test was used to evaluate the statistical power of the model. *p* values of < 0.05 were considered statistically significant.

Approval of Ethics Committee

This study was conducted with the approval of Kütahya Health Sciences University Rectorate Non-Interventional Clinical Research Ethics Committee (Date: 14.07.2020, Decision no.: 2020/11-13).

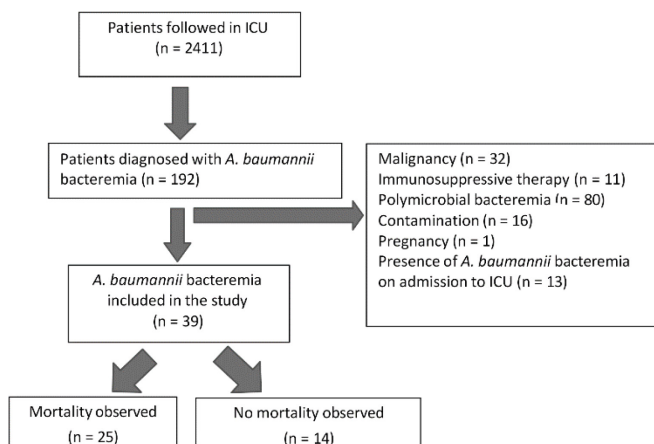
Results

A total of 2411 patients were followed up in the ICU during the study period and the overall mortality rate was 25.09%. Of the 192 patients with healthcare-associated *A. baumannii* bacteremia, 39 patients were included in the study after applying the exclusion criteria. Twenty-five (64.1%) of the patients died (Figure 1). The median age was 72 yrs (range: 54-84 yrs), and 22 (56.4%) were male. The 28-day mortality status of the patients with bacteremia, demographic characteristics, ICU diagnosis, comorbidity status, and SAPS II scores are listed in Table 1. The patients who died were older; SAPS II scores on the ICU admission day were 63 (58-70) vs. 41 (25-51.7) ($p < 0.001$), and the mortality rate [73.6% (62.9-83.8) vs. 27.2% (6.1-50.1); $p < 0.001$] was also higher in the patients who died, as expected.

It was determined that *A. baumannii* bacteremia emerged approximately on the 22nd day of intensive care hospitalization in both groups. Pitt bacteremia scores ($p = 0.01$) and SOFA scores ($p < 0.001$) showed that infection and disease severity on the BD were higher in the mortality group. Except for one of the isolated *A. baumannii* strains, all other patients had MDR or XDR antibiotic resistance. No difference was found when the resistance status and appropriate empirical antibiotic use rates were compared between the groups on BD, and there was no septic shock in any patient. Septic shock was detected in 16 (64%) patients in the mortality group and four (28.6%) in the group without mortality ($p = 0.048$).

Among the invasive procedures, invasive arterial catheterization and endotracheal intubation were performed more frequently in the mortality group, and tracheotomy was performed more frequently in the other group ($p < 0.001$) (Table 2).

Figure 1. Flow chart of the patients included in the study.



ICU: Intensive Care Unit.

Table 1. Demographic characteristics and intensive care admission scores of the patients.

	Mortality group at 28 days after bacteremia (n = 25)	Non-mortality group at 28 days after bacteremia (n = 14)	p value
Age (years)*	75 (69.5-87)	59 (44.7-73.7)	0.02
Gender (F/M)	13/12	4/10	0.19
Intensive care admission diagnoses, n (%)			
Polytrauma	4 (16)	7 (50)	
Post cardiopulmonary arrest	6 (24)	1 (7)	
Pneumonia	5 (20)	1 (7)	
Post-operative	2 (8)	2 (14)	
General condition disorder	2 (8)	1 (7)	
CVE	1 (4)	1 (7)	0.42
Myxedema coma	1 (4)	0	
Subarachnoid hemorrhage	0	1 (7)	
ABI	1 (4)	0	
Syncope	1 (4)	0	
Pulmonary embolism	1 (4)	0	
COPD exacerbation	1 (4)	0	
Comorbidities, n (%)			
No comorbidity	5 (20)	7 (50)	0.07
Hypertension	8 (32)	2 (14)	0.27
COPD	9 (36)	1 (7)	0.06
Parkinson/Dementia/Alzheimer	6 (24)	3 (21)	0.999
Multiple sclerosis/CVE	0	1 (7)	0.35
Chronic liver failure	5 (20)	1 (7)	0.39
Diabetes mellitus	2 (8)	0	0.52
Chronic renal failure	6 (24)	1 (7)	0.38
CAD and heart failure	3 (12)	0	0.54
Chronic atrial fibrillation	1 (4)	1 (7)	0.999
CHARLSON comorbidity index*	1 (0-3)	0 (0-2)	0.31
SAPS II score on the day of admission*	63 (58-70)	41 (25-51.7)	<0.001
Expected mortality rate on the day of admission with SAPS II score (%) *	73.6 (62.9-83.8)	27.2 (6.1-50.1)	<0.001

*: median (IQ25-75); F: Female; M: Male; ABI: Acute Kidney Injury; CAD: Coronary Artery Disease; COPD: Chronic Obstructive Pulmonary Disease; SAPS II: Simplified Acute Physiology Score II; CVE: Cerebrovascular Event.

Table 2. Disease severity scores, resistance status, and invasive interventions on the day of bacteremia.

	Mortality group at 28 days after bacteremia (n = 25)	Non-mortality group at 28 days after bacteremia (n = 14)	p value
<i>Acinetobacter baumannii</i> reproduction day in blood culture (day)*	22 (9.5-37.5)	21.5 (10.7-41.5)	0.84
PITT bacteremia score *	6 (4-8)	3 (2-5.25)	0.010
SOFA score*	11 (10-12.5)	7 (5.7-9.2)	< 0.001
Development of septic shock after the day of bacteremia n (%)	16 (64)	4 (28.6)	0.048
Resistance pattern, n (%)			
MDR	11 (44)	4 (29)	
XDR	14 (56)	9 (64)	0.29
Sensitive	-	1 (7)	
XDR subgroups, n (%)			
Only colistin sensitive	8 (57%)	2 (22%)	0.19
Colistin and tigecycline sensitive	6 (43%)	7 (78%)	
Appropriate empirical treatment, n (%)	12 (48)	7 (50)	0.999
Invasive interventions available on the day of bacteremia, n (%)			
Urinary catheter	25 (100)	14 (100)	
Central venous catheter	24 (96)	13 (92)	
Tracheotomy	2 (8)	6 (42)	
Invasive arterial catheterization	5 (20)	1 (7)	
Hemodialysis catheter	2 (8)	1 (7)	< 0.001
Nasogastric tube	20 (80)	13 (92)	
Percutaneous pleural drainage	1 (4)	0	
Endotracheal intubation	23 (92)	8 (57)	

*: median (IQ25-75); MDR: Multidrug Resistant; SOFA: Sequential Organ Failure Assessment; XDR: Extensively Drug Resistant.

When the hemogram parameters on the BD were examined, it was found that there were significant differences in the mortality group; plateletocrit (PCT) was lower ($p = 0.036$) and RDW was increased ($p < 0.001$). CRP was higher ($p = 0.002$), and albumin was significantly lower ($p = 0.009$) in the mortality group. We analyzed the neutrophil %/albumin ratio because it increases in systemic acute inflammation and is related to mortality; as expected, it was higher in the mortality group ($p = 0.018$) (Table 3).

ROC curves were drawn for the variables found to be significant according to the results of univariate analyses and cut-off points were determined; RDW was found to be the variable that best-predicted mortality, with an area under the ROC curve (AUC) of 0.94 ($p < 0.001$). The cut-off point was 14.65; sensitivity and specificity values were 92% and 93%, respectively (Table 4) (Figure 2).

Multivariate analysis was performed to evaluate risk factors on the BD for 28-day mortality due to *A. baumannii* bacteremia; CRP [OR: 1.02, 95% CI: [1.004-1.055]; $p = 0.025$] and RDW (OR: 11.35, 95% CI: [1.540-83.69]; $p = 0.017$) were found to be independent risk factors for mortality.

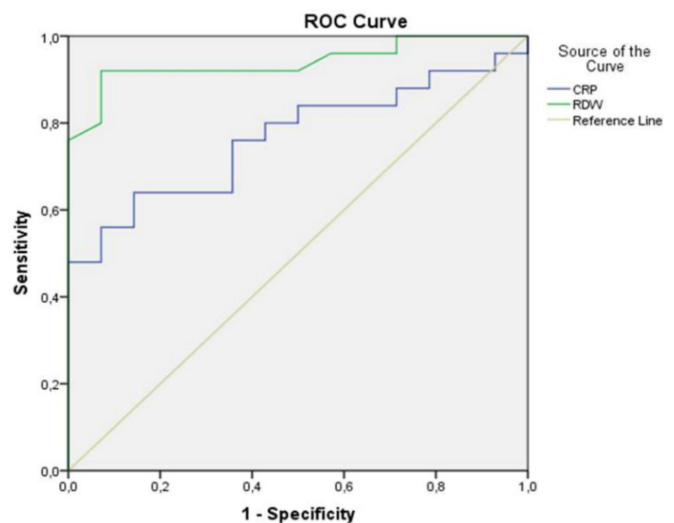
In the grouping made by considering the cut-off points of the CRP and RDW variables, when both parameters were positive at the same time, for 28-day mortality after BD, the sensitivity was 72%, the specificity was 100%, the negative predictive value was 33%, and the positive predictive value was 100%.

The average length of stay in the ICU were 40 (25.5-49) and 73 (55-128) days in the groups with and without mortality, respectively ($p = 0.001$).

Discussion

Our analysis of 28-day mortality due to healthcare-associated *A. baumannii* bacteremia arising in the ICU, identified SOFA and PITT bacteremia scores, CRP, RDW values, and the neutrophil %/albumin ratio on the BD to be higher in the mortality group. We determined

Figure 2. ROC curves of CRP (AUC = 0.76, $p = 0.006$) and Erythrocyte Distribution Width (RDW) parameters (AUC = 0.94, $p < 0.001$) determined on the day of bacteremia for 28-day mortality in *Acinetobacter baumannii* bacteremia.



CRP: C-Reactive Protein; RDW: Red Cell Distribution Width.

Table 3. Laboratory values showing the severity of infection on the *Acinetobacter baumannii* bacteremia day.

	Mortality group at 28 days after bacteremia (n = 25)	Non-mortality group at 28 days after bacteremia (n = 14)	p value
WBC count (/μL)*	12.2 (6.85-17.2)	12.69 (9.84-17.12)	0.57
Neutrophil count (/μL)*	10.22 (5.61-15.65)	10.65 (7.24-15)	0.71
Neutrophil percentage (%)*	90.4 (82.9-94)	85.1 (75.4-91)	0.09
Lymphocyte count (/μL)*	0.61 (0.44-1.19)	0.94 (0.62-1.62)	0.07
Platelet count (/μL) †	205 ± 118	249 ± 151	0.32
Hemoglobin (g/dL)†	10.1 ± 1.35	10.37 ± 1.32	0.54
MPV (fL)†	10.11 ± 1.46	9.26 ± 1.23	0.07
PDW (%)*	16.7 (16.1-18.1)	16.9 (16.3-18.1)	0.42
PCT (%)*	0.12 (0.10-0.16)	0.20 (0.12-0.32)	0.036
RDW (%)*†	17.94 ± 2.91	14.1 ± 0.68	< 0.001
CRP (mg/L) †	205.9 ± 105.4	127.8 ± 38.8	0.002
Albumin (g/dL)†	2.36 ± 0.38	2.68 ± 0.26	0.009
Neutrophil/Albumin ratio†	4.83 ± 2.87	4.18 ± 1.51	0.35
Neutrophil(%)/Albumin ratio†	37.1 ± 7.89	31.2 ± 5.39	0.018
Glucose (mg/dL)*	166 (125-205)	115 (103-139)	0.03
Lactate (mmol/L)*	1.3 (0.75-2.05)	0.95 (0-1.15)	0.027
Neutrophil/lymphocyte ratio*	15.77 (7.52-29.77)	8.87 (6.45-18.53)	0.33
Thrombocyte/lymphocyte ratio*	218 (152-450)	193 (148-313)	0.40

*: median (IQ25-75); †: mean±SD; CRP: C-reactive protein; MPV: Mean Platelet Volume; PDW: Thrombocyte Distribution Width; PCT: Plateletocrit; RDW: Red Blood Cell Distribution Width; WBC: Leukocyte.

that when CRP and RDW values on the BD increased, mortality increased independently.

Various scoring systems have been used to predict patient prognosis in the ICU during their hospitalization and follow-up. One of them, SAPS II scoring, evaluates organ dysfunction at admission to the ICU and can predict mortality, especially in sepsis and septic shock. Godinjak *et al.* found the sensitivity and specificity for mortality as 90.2% and 75.7%, respectively, in patients with SAPS II scores above 50.5 at ICU admission [16]. Another study evaluating patients infected with MDR *A. baumannii* and carbapenemase-producing *Klebsiella pneumoniae* showed that SAPS II scores above 45 were associated with increased mortality [17]. Despite the small number of patients in our study, it should be emphasized that a homogeneous case profile of bacteremia only caused by *A. baumannii* was examined. Our cut-off value for SAPS II at admission was 55.5. The sensitivity and specificity for mortality in patients with *A. baumannii* bacteremia during follow-up were 84% and 86%, respectively. Therefore, as the severity of organ dysfunction increased at the time of admission, the likelihood of developing septic shock and the mortality rate due to *A. baumannii* bacteremia increased during follow-up. Unlike previous reports, we performed modelling using variables on the BD to investigate the risk factors for 28-day mortality after bacteremia. These parameters should be considered in analyses with larger patient series.

In our study, two different scoring systems were used on the BD. The first was the SOFA scoring in the definition of Sepsis-3, which was used to evaluate organ dysfunction and diagnose sepsis [4]. The SOFA score calculated at the time of bacteremia is closely associated with sepsis mortality due to bacteremia [4,18]. Oh *et al.* evaluated the SOFA on the BD due to Gram-positive and negative organisms and demonstrated that SOFA scores ≥ 9 increased 90-day mortality by 2.88-fold [19]. Chen *et al.* examined the relationship between the scoring system and mortality

only in patients with carbapenem-resistant *A. baumannii* bacteremia. They found a significant relationship between SOFA scores ≥ 8 and 14-day mortality with a sensitivity of 90% [20]. The second scoring system used to determine the mortality risk was Pitt bacteremia scoring. In this system, the clinical conditions of the patients such as body temperature, blood pressure, mental status, mechanical ventilation, and presence of cardiac arrest were evaluated on the BD. In evaluations with results between 0 and 14 points, it was stated that ≥ 4 points showed a correlation between severity of bacteremia and mortality [21]. Güneş *et al.* showed this correlation in a patient group where only Gram-negative bacterial infections were evaluated [15]. In our study, almost all of the patients had XDR or MDR bacteremia. In previous studies when the cut-off point of SOFA calculated on the BD was 9.5, it was seen that it could be used to predict 28-day mortality with high sensitivity (84%) and specificity (79%). Similarly, although the Pitt bacteremia scores were higher in the mortality group when the cut-off point was accepted as 3.5, we saw that the sensitivity was 84% and the specificity remained at 58%. As a result, the Pitt bacteremia score seems to be less effective in mortality prediction compared with SAPS II calculated on the day of admission and SOFA scores on the BD. Daily follow-up of SOFA scores, especially in older patients with high SAPS II scores, prolonged hospitalization (> 20 days), and invasive procedures, can predict the prognosis. Bacteremia and sepsis, which may cause high mortality, should be considered when there is a two-unit increase in the SOFA score or when the SOFA score specified in the studies mentioned above reaches a certain value.

Unfortunately, it is not possible to determine the first entry of bacteria into the bloodstream in asymptomatic patients without any clinical and laboratory data. As an important note, hyper inflammation is prominent at the time of diagnosis of sepsis due to bacteremia. The resulting inflammatory

Table 4. ROC analysis results of clinical and laboratory parameters affecting mortality in *Acinetobacter baumannii* bacteremia.

	Cut-off Point	AUC	p value	95% CI	Sensitivity	Specificity
Age (years)	65	0.72	0.020	0.56-0.89	0.84	0.58
SAPS II score on admission day	55.5	0.89	< 0.001	0.82-0.99	0.84	0.86
SOFA score on the day of bacteremia	9.5	0.85	< 0.001	0.72-0.99	0.84	0.79
PITT bacteremia score	3.5	0.75	0.010	0.58-0.91	0.84	0.58
CRP (mg/dL)	129	0.76	0.006	0.61-0.91	0.80	0.58
RDW (%)	14.65	0.94	< 0.001	0.86-1.0	0.92	0.93
Albumin Level	2.55	0.74	0.011	0.59-0.90	0.64	0.65
Neutrophil(%) /Albumin ratio	32.41	0.71	0.026	0.55-0.87	0.76	0.58

CRP: C-Reactive Protein; RDW: Red Blood Cell Distribution Width; SAPS II: Simplified Acute Physiology Score II; SOFA: Sequential Organ Failure Assessment Score.

burden reflects the severity of the infection and consequently signifies an increased risk of mortality [22]. In such cases, it could be life-saving to recognize this situation early and start effective antibiotic therapy as early as possible [23]. For this reason, various studies have been conducted to diagnose sepsis with proinflammatory markers early before the clinical picture is established. Approximately 258 biomarkers, such as proinflammatory cytokines interleukin (IL)-6 and monocyte chemoattractant protein (MCP-1) are associated with prognosis and mortality at the time of sepsis diagnosis [24]. However, in daily life, their use is often impossible due to their impracticality, accessibility, and cost. The relationship between high glucose [25], RDW [26,27], CRP [9,22,28], lactate [4,27], neutrophil %/albumin [29] levels and mortality has been investigated in previous studies. Also, an association between low albumin [9,27], PCT [30] levels, and mortality was studied. Mortality was due to sepsis and septic shock caused by bloodstream infection. However, none of these studies were performed using data from the *A. baumannii* BD. Hence, to our knowledge, our study is the first to evaluate any relationship between laboratory values on the BD and mortality and provides a cut-off value.

CRP produced as an acute-phase reactant is a well-defined biomarker for infection and inflammation with its proinflammatory effect [22]. In an infection that progresses to sepsis, increased neutrophil count and the neutrophil percentage are predictive of bacteremia and associated blood-borne infection [29]. Low albumin levels are also associated with severe systemic inflammation, sepsis, septic shock, organ failure, and resulting mortality [31]. In our study, it was shown that CRP and neutrophil %/albumin ratio on BD were significantly higher in the mortality group. In the analysis, it was determined that both parameters were acceptably effective in estimating mortality. Gong *et al.* showed that if the cut-off value of the neutrophil %/albumin ratio was > 31.4 within the first 24 hours after ICU admission, 30-day mortality would be 34.12% [29]. In our study, we found that 76% of the patients died when the cut-off value was > 32.41 on the BD. An increase in the neutrophil %/albumin ratio in sepsis conditions is not surprising with the mechanisms mentioned above. When all the results are evaluated, considering that there is no neutrophil (%) difference between groups with or without bacteremia-associated mortality, it can be thought that any decrease in the albumin levels is more effective in predicting mortality. In addition, as a result of multivariate analysis, it was

seen that the neutrophil %/albumin ratio was not a risk factor for mortality.

RDW, which can be determined in a simple hemogram analysis and is not usually used for follow-up, is a measure of variation and heterogeneity in erythrocyte size. RDW value increases as a result of the change in erythrocyte homeostasis with systemic inflammation and oxidative stress. It is a poor prognosis indicator for systemic infection, sepsis, and septic shock and is associated with increased mortality [27]. In our study, the RDW level on BD was found to be the best parameter to predict mortality, with the AUC at 94%. Its sensitivity and specificity were 92% and 93%, respectively, when the cut-off value was accepted as 14.65%. It remained almost the only variable affecting mortality in the correction of analysis results, and it was shown that a 1-unit increase in RDW caused a 13-fold increase in mortality. On the BD, especially in the “combined” evaluation made with CRP, when both variables were above the cut-off values, the positive predictive value for 28-day mortality was found as 100%. In addition, although these laboratory parameters on the BD indicated mortality, it was remarkable that none of the patients had a septic shock on BD. Therefore, elevated RDW and CRP levels together reflect severe inflammation on the BD and may predict septic shock and mortality as a consequence of the hyperinflammation.

However, there are some limitations to our study. In addition to being a retrospective and single-centre study, we included only a small number of patients in the study after applying the exclusion criteria. However, when evaluating this, the low rate of monobacterial *A. baumannii* bacteremia due to the success of health care and the characteristics of patients who may develop bacteremia in the ICU should be taken into account. The reason for the small number of patients was our rigorous exclusion criteria which were specified to minimize confounding factors. On the other hand, in our study conducted in an ICU in a developing country, routinely used hemogram and biochemical parameters, and low-cost scoring systems were evaluated. CRP and RDW values do not require additional intervention and cost; they are simple parameters that can indicate bacteremia and patient prognosis.

Conclusions

High SOFA and SAPS II scores, advanced age, and invasive procedures are associated with mortality in ICUs. According to the results of multivariate analysis, CRP and RDW values on the BD were determined as

independent risk factors for mortality. With monitoring and follow-up of these parameters in addition to our daily clinical evaluation, when certain thresholds are met indicating that bacteremia with high mortality is approaching, it may be possible to reduce the probability of death by making the necessary evaluations with early clinical suspicion, early assessment of infection, taking samples early and, if necessary, by early initiation of empirical treatment without waiting for hypo-hyperthermia. This may prevent the development of sepsis and septic shock and reduce the possibility of mortality. To our knowledge, this is the first report on a homogeneous case group in terms of bacteremia. Further evaluation of these results with larger patient series is recommended.

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Authors' contributions

MET and SA conceived and designed the study. MET, DPR, and EY performed the tests. ÖA and PK analyzed the data and MET wrote the manuscript. PK, CB, and DPR supervised the study. All authors read, provided feedback and approved the final manuscript.

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