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Construction and Validation of a Predictive Model for Mortality Risk in Patients with *Acinetobacter baumannii* Bloodstream Infection

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Purpose: To develop and validate a predictive model for the risk of death in patients with *Acinetobacter baumannii* (*A. baumannii*) bloodstream infection (BSI) for clinical decision-making and patient management.

Methods: In this study, we included demographic and clinical data from 206 patients with *Acinetobacter baumannii* BSI in China between January 2013 and December 2023. Variables were screened by least absolute shrinkage and selection operator (LASSO) regression and multivariate Cox regression, and prognostic models and nomograms were constructed. The models were evaluated using the area under curve (AUC) of Receiver Operating Characteristic (ROC), decision curve analysis (DCA), and standard curves to evaluate the model.

Results: Comorbid septic shock, an elevated neutrophil/lymphocyte ratio (NLR), low hemoglobin (HGB) levels, and low platelet counts (PLT) were found to be independent risk factors for death in patients with *A. baumannii* BSI. With the models constructed from these four variables, the AUCs of the ROC curves of the test and validation cohorts for the prognostic scenarios at 7, 14, and 28 days were not less than 0.850, and the AUCs of the ROC curves of the risk-of-death prediction model were the highest for both groups at 7 days, at 0.907 and 0.886, respectively. The two sets of calibration curves show that the calibration curves oscillate around a 45° diagonal line at 7, 14, and 28 days, and there is a good correlation between the actual risk and the predicted risk, with a high degree of calibration.The clinical decision curve shows that the model has a strong discriminatory ability when the probability is between 10% and 70%.

Conclusion: Septic shock status, NLR, HGB and PLT are independent risk factors for 28-day mortality in patients with *A. baumannii* BSI. These variables are conveniently and readily available, and in patients with *A. baumannii* BSI these indicators can be closely monitored in clinical practice and timely interventions can be made to improve prognosis.

Keywords: *Acinetobacter baumannii*, bloodstream infection, predictive model, septic shock

Introduction

A. baumannii is one of the pathogens responsible for the greatest increase in the global healthcare disease burden.[1] *A. baumannii* often causes respiratory, urinary tract and bloodstream infections,[2] and the infections it causes pose a significant threat in health care settings, leading to increased treatment costs, prolonged hospital stays, and increased mortality,[1,3] and exploring the clinical characteristics and risk factors for mortality in patients with A. baumannii BSI is of great benefit to clinical work.

Although some progress has been made in recent years in the study of the pathogenesis of BSI and its treatment, *A. baumannii* and the BSI it causes can lead to poor prognosis and high mortality after infection due to, among other reasons, dysregulation of the host's response to infection.[4,5] In addition, there is no specific drug for the treatment of BSI, so early detection, early prevention and early intervention are the main diagnostic and therapeutic measures to reduce the

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morbidity and mortality of BSI. In clinical work, the treatment of *A. baumannii* BSI is complex and requires timely diagnosis and appropriate antibiotic therapy to improve patient prognosis.[4]

A number of clinical and microbiologic parameters, including the occurrence of septic shock and decreased platelet count, have been identified as potential predictors of mortality in these patients.[6] To date, few studies have investigated the predictors of outcomes in patients with *A. baumannii* bacteraemia, particularly with regard to overall survival (OS). Therefore, we conducted a retrospective analysis of up to 13 years. The 13-year time span enhances the value of epidemiological characterisation of *A. baumannii* BSI, and studies with a long time span can help to identify and validate risk factors associated with prognosis, and can more accurately assess the mortality rate of *A. baumannii* BSI. On the other hand, in previous prognostic model construction,[6] variable screening using single-factor analysis followed by multifactorial analysis is prone to overfitting problems, and the constructed model lacks specificity and accuracy, which can lead to suboptimal clinical decision-making. Therefore, a more rigorous screening of model variables needs to be utilised to improve the accuracy of prognostic prediction in these patients. In this study, we screened variables using LASSO regression by collecting a wide range of variables such as patients' underlying diseases and laboratory indicators, using Cox regression analysis and building nomograms to provide clinicians with a tool to predict patients' prognosis and guide treatment decisions in this challenging clinical situation.

Patients and Methods

Study Design

The relevant demographic and clinical data of 249 patients with *A. baumannii* BSI admitted to the ward of the Guangdong Provincial Second Hospital of Traditional Chinese Medicine for 13 consecutive years from January 2011 to December 2023 were collected.

The inclusion criteria were as follows:

1. Patients who were diagnosed with *A. baumannii* BSI: isolation of *A. baumannii* by blood culture on the basis of clinical diagnosis. Clinical diagnosis requires: fever >38°C or hypothermia <36°C, which may be accompanied by chills, combined with one of the following conditions: 1) invasive portal or migratory foci; 2) systemic symptoms of toxicity without obvious foci of infection; 3) rash or haemorrhagic spots, liver and spleen enlargement, and blood neutrophilia with left shift of the nucleus, which cannot be explained by any other reasons; 4) systolic blood pressure lower than 12kPa (90mmHg), or a decrease of more than 5.3kPa (40mmHg) from the original systolic blood pressure.
2. Patients with *A. baumannii* BSI aged ≥18 years at diagnosis.
3. Non-duplicate patients who have completed follow-up. If there were multiple blood culture isolations of *A. baumannii*, information was collected on the patient's first positive blood culture. Patients with incomplete follow-up data such as underlying disease at the time of infection, laboratory results data, and patients with uncertain survival outcomes after 28 days were excluded. Because of the long time span and the observation of 28-day post-infection survival is a relatively long period of time, some patients could not be contacted for follow-up after discharge to determine whether they survived 28 days post-infection, which was deleted to ensure the reliability of the results, and may have had an impact on the true mortality rate after *A. baumannii* BSI in this study.

A total of 206 patients with *A. baumannii* BSI were included in this study based on the inclusion and exclusion criteria. Based on the time of diagnosis, 160 patients from 2011 to 2020 were categorized into a training cohort, and 46 patients from 2021 to 2023 were categorized into a test cohort. Based on the number of included cases, LASSO regression was chosen to screen the variables in order to better improve the selection of model features and reduce problems such as overfitting of traditional models. Cox regression analysis was used to identify significant prognostic factors for 28-day survival, and a Cox regression model was constructed and validated by receiver operating characteristic (ROC) curve analysis, calibration curve analysis, and decision curve analysis (DCA). Figure 1 shows the workflow of this study.

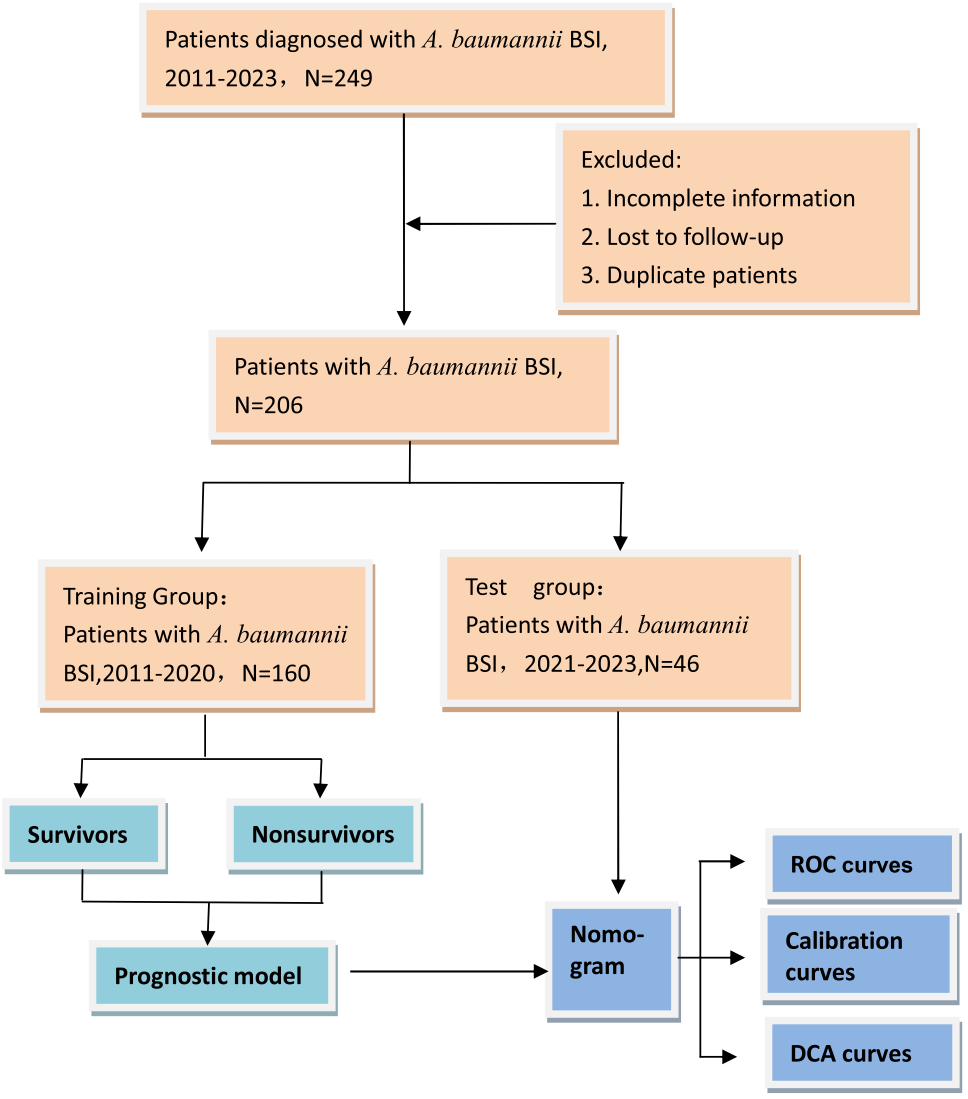

Figure 1 Study design.

Data Collection

The following demographic information and clinical data were collected for a total of 17 risk factors based on the number of patients as well as patient characteristics: sex, age, whether the infection was associated with underlying disease (pneumonia, hypertension, cerebral infarction), invasive operation (mechanical ventilation, peripherally inserted central catheter (PICC), indwelling urinary catheters), whether there was a combination of septic shock, whether the infecting strain was CRAb (Carbapenem-resistant *Acinetobacter baumannii*), white blood cell count (WBC), neutrophil-to-lymphocyte ratio (NLR), hemoglobin (HGB), platelet count (PLT), aminotransferase (AST), blood glucose (GLU), and creatinine (CR) at sampling time for positive blood cultures or within 24 hours. Survival status represents the survival of A. baumannii positive blood cultures 28 days after the time of delivery. Survival at 7, 14 and 28 days after the time of delivery of positive blood cultures was analysed in the COX regression analysis model.

Data Analysis

In this study, patient survival status within 28 days was used as the dependent variable, 17 demographic and clinical data points were used as independent variables, and univariate analyses were performed using the chi-square test or Fisher's

exact test for categorical variables and *t* test or rank-sum test for continuous variables. Nonnormally distributed data are expressed as medians (interquartile ranges).

Statistical analyses were performed using R software (version 4.3.1). LASSO regression was used for the 17 independent variables in the training cohort to screen for variables at lambda.min, and the screened variables were included in the multifactorial Cox regression analyses; LASSO regression is performed with the glmnetR package. Variables with Cox regression analyses of $P < 0.10$ were used to create prognostic models. Based on the Cox regression analysis model for the training cohort obtained in the previous step, a nomogram prediction model was built by regression coefficients. The nomogram is performed with the replotR package. The validation group data were then prospectively evaluated. The performance of the model was assessed by ROC curves and calibration curves. DCA was used to determine the predicted net benefit threshold. ROC curves, calibration curves and DCA were obtained using R packages such as timeROC, ggplot2 and dcurves, respectively.

Results

Demographics and Characteristics of the Training and Testing Cohort

In this study, 206 patients had an overall 28-day mortality rate of 25.7% (53/206), 160 patients in the training cohort had a 28-day mortality rate of 27.5% (44/160), and 46 patients in the test cohort had a mortality rate of 19.6% (9/46); there was no significant difference in mortality rates between the two groups. There were also no significant differences in 17 variables, such as sex (male), age, or underlying medical conditions, between the two groups (Table 1).

Independent Prognostic Factors in Patients with A. baumannii BSI

According to the one-way Cox analysis, 11 variables, pneumonia, mechanical ventilation, PICC, indwelling urinary catheter, septic shock, CRAb, WBC, NLR, HGB, PLT, and AST were found to be associated with OS in patients with *A. baumannii* BSI ($p < 0.05$) (Table 2).

Table 1 Patient Demographics and Baseline Characteristics

Characteristic	Cohort		*P* value[b]
	Training Cohort, N = 160[a]	Test Cohort, N = 46[a]	
Status			0.278
Survival	116 (72.5%)	37 (80.4%)	
Death	44 (27.5%)	9 (19.6%)	
Male			0.543
No	60 (37.5%)	15 (32.6%)	
Yes	100 (62.5%)	31 (67.4%)	
Pneumonia			0.417
No	111 (69.4%)	29 (63.0%)	
Yes	49 (30.6%)	17 (37.0%)	
Hypertension			0.564
No	62 (38.8%)	20 (43.5%)	
Yes	98 (61.3%)	26 (56.5%)	
Cerebral_infarction			0.672
No	96 (60.0%)	26 (56.5%)	
Yes	64 (40.0%)	20 (43.5%)	
Mechanical_ventilation			0.215
No	114 (71.3%)	37 (80.4%)	
Yes	46 (28.8%)	9 (19.6%)	
PICC			0.656
No	88 (55.0%)	27 (58.7%)	
Yes	72 (45.0%)	19 (41.3%)	

(*Continued*)

Table 1 (Continued).

Characteristic	Cohort		*P* value[b]
	Training Cohort, N = 160[a]	Test Cohort, N = 46[a]	
Indwelling urinary catheter			0.600
No	87 (54.4%)	23 (50.0%)	
Yes	73 (45.6%)	23 (50.0%)	
Septic_shock			0.417
No	139 (86.9%)	42 (91.3%)	
Yes	21 (13.1%)	4 (8.7%)	
CRAb			0.348
No	92 (57.5%)	30 (65.2%)	
Yes	68 (42.5%)	16 (34.8%)	
Age			0.145
Median (Q1, Q3)	76 (66, 83)	72 (53, 84)	
WBC			0.527
Median (Q1, Q3)	9 (6, 13)	8 (5, 13)	
NLR			0.385
Median (Q1, Q3)	11 (6, 18)	9 (5, 15)	
HGB			0.070
Median (Q1, Q3)	97 (79, 121)	111 (89, 127)	
PLT			0.185
Median (Q1, Q3)	192 (135, 266)	215 (144, 270)	
AST			0.295
Median (Q1, Q3)	28 (19, 43)	30 (21, 57)	
GLU			0.152
Median (Q1, Q3)	6.83 (5.23, 8.93)	6.31 (5.19, 7.89)	
CR			0.703
Median (Q1, Q3)	72 (54, 104)	73 (51, 95)	

Notes: [a]n (%);[b]Wilcoxon rank sum test; Pearson's Chi-squared test; Welch Two Sample *t*-test.
Abbreviations: PICC, peripherally inserted central catheter; CRAb, carbapenem-resistant *Acinetobacter baumannii*; WBC, White blood cell count; NLR, Neutrophil-to-lymphocyte ratio; HGB, Hemoglobin; PLT, Platelet count; AST, Aminotransferase; GLU, Blood glucose; CR, Creatinine.

Table 2 Results of Univariate Cox Regression

Characteristic	N	Event N	HR[a]	95% CI[b]	*P* value
Male					
No	60	14			
Yes	100	30	1.32	0.70, 2.50	0.387
Pneumonia					
No	111	24			
Yes	49	20	2.15	1.19, 3.90	0.011
Hypertension					
No	62	22			
Yes	98	22	0.58	0.32, 1.04	0.068
Cerebral_infarction					
No	96	27			
Yes	64	17	0.92	0.50, 1.69	0.792

(*Continued*)

Table 2 (Continued).

Characteristic	N	Event N	HR[a]	95% CI[b]	*P* value
Mechanical_ventilation					
No	114	19			
Yes	46	25	4.39	2.41, 7.98	<0.001
PICC					
No	88	11			
Yes	72	33	4.63	2.34, 9.18	<0.001
Indwelling urinary catheter					
No	87	10			
Yes	73	34	5.17	2.55, 10.49	<0.001
Septic_shock					
No	139	25			
Yes	21	19	13.88	7.36, 26.17	<0.001
CRAb					
No	92	10			
Yes	68	34	5.78	2.85, 11.71	<0.001
Age	160	44	1.02	1.00, 1.04	0.102
WBC	160	44	1.04	1.00, 1.07	0.031
NLR	160	44	1.01	1.00, 1.01	0.003
HGB	160	44	0.98	0.97, 0.99	<0.001
PLT	160	44	0.99	0.99, 1.00	<0.001
AST	160	44	1	1.00, 1.00	<0.001
GLU	160	44	1.05	0.98, 1.13	0.187
CR	160	44	1	1.00, 1.00	0.344

Notes: [a]HR, Hazard Ratio;[b] CI, Confidence Interval.
Abbreviations: PICC, peripherally inserted central catheter; CRAb, carbapenem-resistant *Acinetobacter baumannii*; WBC, White blood cell count; NLR, Neutrophil-to-lymphocyte ratio; HGB, Hemoglobin; PLT, Platelet count; AST, Aminotransferase; GLU, Blood glucose; CR, Creatinine.

The candidate predictors male, pneumonia, hypertension, cerebral infarction, mechanical ventilation, PICC, indwelling urinary catheter, septic shock, CRAb, age, WBC, NLR, HGB, PLT, AST, GLU, and CR were included in the original model and subsequently reduced to 8 potential predictors via LASSO regression analysis of the training cohort. The most regularized and parsimonious models, with a cross-validated error within one standard error of the minimum, included PICC, septic shock, CRAb, NLR, HGB, PLT, and AST. A coefficient profile and a cross-validated error plot of the LASSO regression model are shown in Figure 2.

The 8 variables obtained from LASSO regression were subjected to multifactorial Cox analysis, and 4 variables with P<0.1 were ultimately identified as independent prognostic factors, including septic shock status, the NLR, HGB, and the PLT (Tables 3 and 4).

Development and Validation of the Nomogram

Based on the identified independent prognostic factors, we developed a nomogram to predict OS at 7, 14, and 28 days for patients with *A. baumannii* BSI (Figure 3).

The C-index (95% CI) was 0.819 (0.752, 0.886) for the training cohort nomogram and 0.833 (95% CI: 0.708,0.958) for the validation cohort, suggesting that the predictive model has sufficient discriminative ability. The ROC curves showed that the AUCs reached 0.907, 0.872 and 0.859 for 7, 14 and 28 days, respectively, in the training cohort and 0.886, 0.850 and 0.850, respectively, in the validation cohort, which indicated that the model had good discriminatory ability. A comparison of the nomogram with the ROC curves for each prognostic factor showed that the composite model had a greater degree of discrimination than any individual variable in both groups (Figure 4A–D). The calibration curves

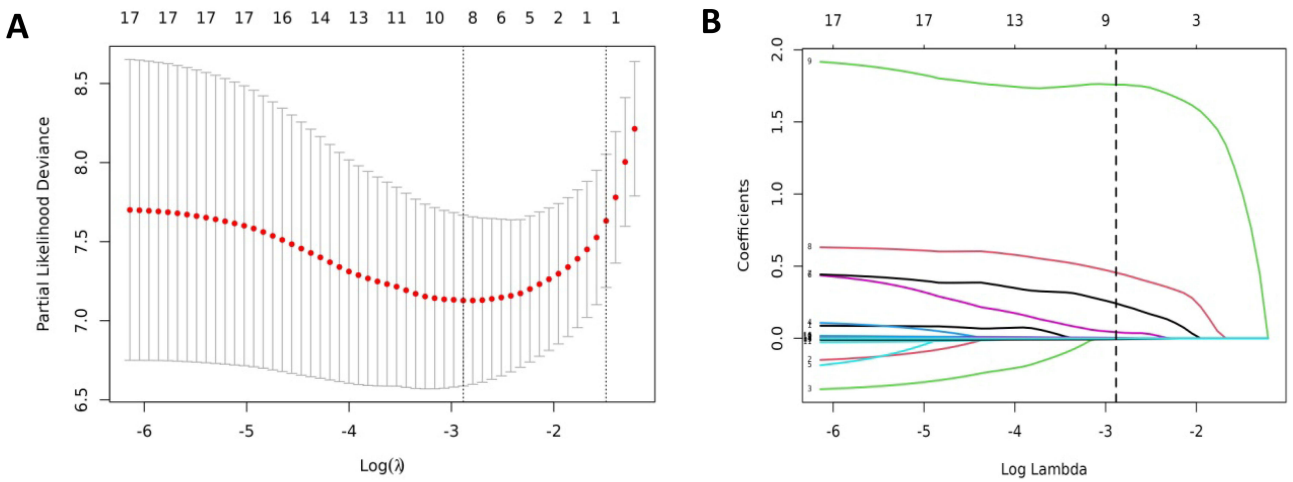

Figure 2 (**A**) LASSO regression a LASSO regression cross-validation plot; (**B**) LASSO regression coefficient path plot.

for the two groups showed a high degree of agreement between the actual observations and the results predicted by the nomogram (Figure 5).

The DCA analysis shows that the net benefit of the proposed model is high and has a wide range of threshold probabilities. The decision curves of the model for the three time points of 7, 14, and 28 days in the training cohort provided good net benefits in the range of 10%-70%, with a wider range of 14 and 28 days, which provided good net benefits in the range of 10–100% (Figure 6A). The use of the original model in the validation cohort was efficient, with high benefits in the range of 20–80% (Figure 6B).

Table 3 Results of Multivariate Cox Regression Analysis for the Training Cohort

Characteristic	N	Event N	HR[a]	95% CI[b]	*P* value
PICC					
0	88	11			
1	72	33	1.12	0.38, 3.25	0.838
Indwelling urinary catheter					
0	87	10			
1	73	34	1.49	0.46, 4.81	0.505
Septic_shock					
0	139	25			
1	21	19	6.77	3.15, 14.55	<0.001
CRAb					
0	92	10			
1	68	34	1.94	0.78, 4.83	0.157
NLR	160	44	1.01	1.00, 1.01	<0.001
HGB	160	44	0.99	0.97, 1.00	0.076
PLT	160	44	1	0.99, 1.00	0.032
AST	160	44	1	1.00, 1.00	0.363

Notes: [a]HR, Hazard Ratio; [b]CI, Confidence Interval. Number in dataframe = 160, Number in model = 160, Missing = 0, Number of events = 44, Concordance = 0.854 (SE = 0.026), R-squared = 0.402 (Max possible = 0.933), Likelihood ratio test = 82.372 (*df* = 8, p = 0.000), C index (95% CI) = 0.854 (0.802, 0.905).

Abbreviations: PICC, peripherally inserted central catheter; CRAb, carbapenem-resistant *Acinetobacter baumannii*; NLR, Neutrophil-to-lymphocyte ratio; HGB, Hemoglobin; PLT, Platelet count; AST, Aminotransferase; GLU, Blood glucose; CR, Creatinine.

Table 4 Results of Multivariate Cox Regression for the Training Cohort

Characteristic	N	Event N	HR[a]	95% CI[b]	*P* value
Septic_shock					
No	139	25			
Yes	21	19	11.22	5.72, 22.02	<0.001
NLR	160	44	1.01	1.00, 1.01	<0.001
HGB	160	44	0.98	0.97, 0.99	0.003
PLT	160	44	1.00	0.99, 1.00	0.015

Notes: [a]HR, Hazard Ratio; [b] CI, Confidence Interval. Number in dataframe = 160, Number in model = 160, Missing = 0, Number of events = 44, Concordance = 0.819 (SE = 0.034), R-squared = 0.380 (Max possible = 0.933), Likelihood ratio test = 72.76 (*df* = 4, p = 0.000), C index (95% CI) = 0.819 (0.752, 0.886)

Abbreviations: NLR, Neutrophil-to-lymphocyte ratio; HGB, Hemoglobin; PLT, Platelet count.

Discussion

In this study, we developed and validated a nomogram for predicting the prognosis of patients with *A.*baumannii BSI based on a cohort of 206 patients with *A. baumannii* BSI. The predictors of the nomogram included the presence or

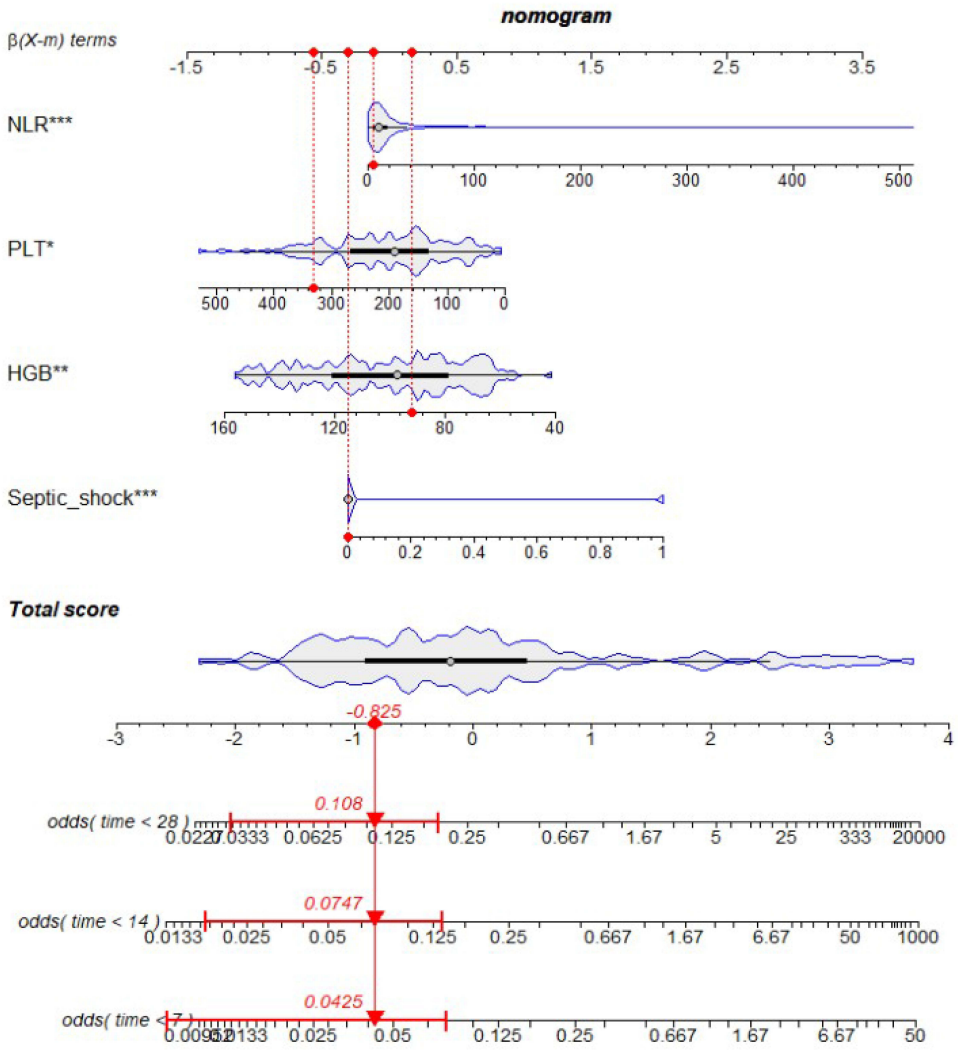

Figure 3 Nomogram prediction model.

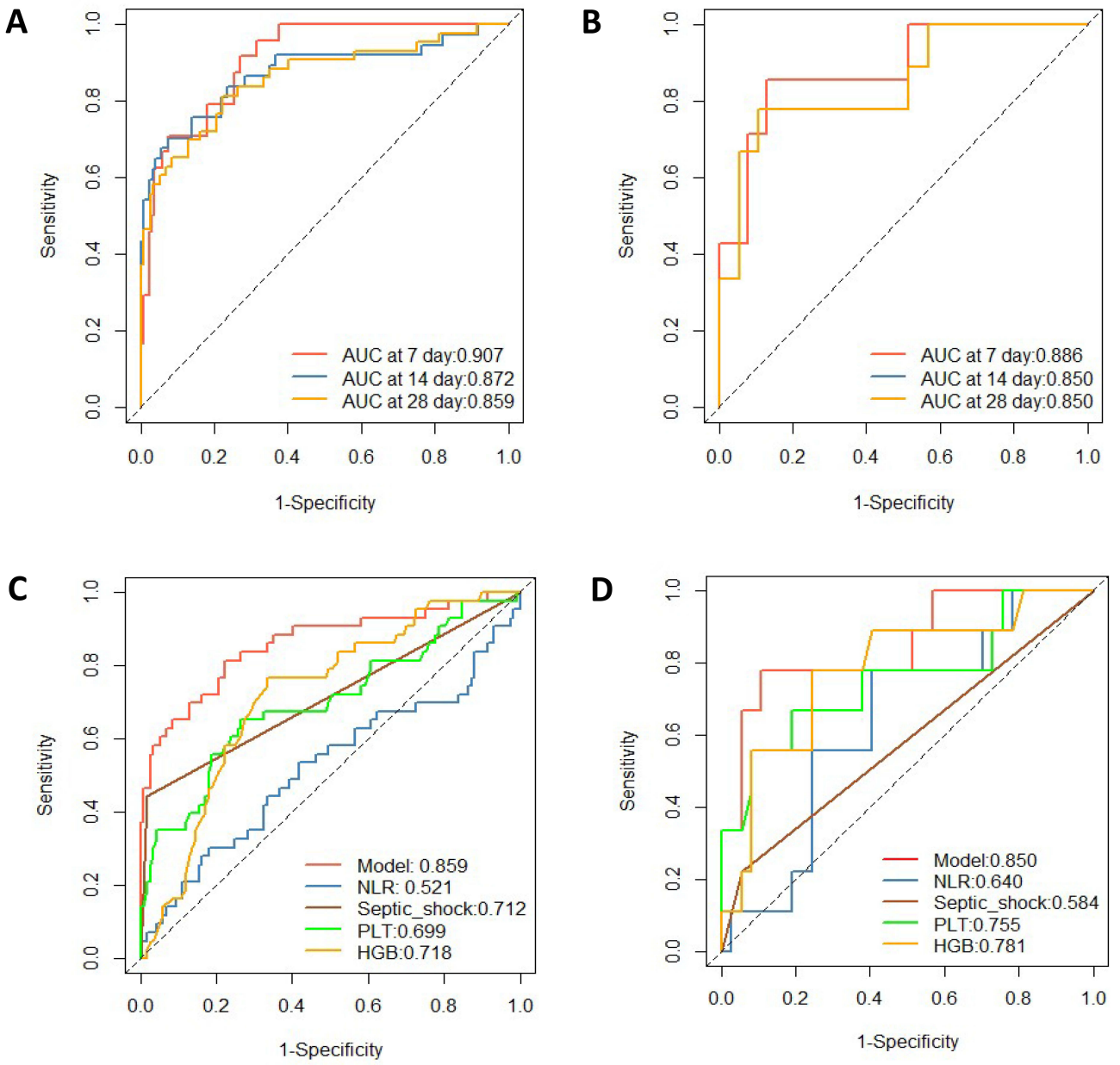

Figure 4 (**A**) ROC curves at different times in the training cohort; (**B**) ROC curves at different times in the test cohort (The 14-day and 28-day AUC curves were the same, and the 14-day AUC curve was overridden by the 28-day AUC curve.); (**C**) ROC curves at 28 days for different variables in the training cohort; (**D**) ROC curves at 28 days for different variables in the test cohort.

absence of comorbid septic shock after infection and the NLR, PLT, and HGB at the time of infection, which were statistically significant in the multivariate Cox regression analysis.

According to our model, the presence or absence of comorbid septic shock after infection was a significant risk factor for the risk of death from *A.*baumannii BSI. Septic shock usually refers to severe infection, which usually occurs in critically ill patients who are more likely to die after a fatal blow. Studies have shown that patients with severe disease have higher APACHE and SOFA scores and significantly greater infectious mortality.[7,8] On the other hand, this suggests that *A. baumannii* has high virulence. In the past, *A. baumannii* was considered a low-virulence opportunistic pathogen[9] and is one of the colonizing bacteria in the respiratory tract and other parts of the body with weak virulence. Recent studies have shown that colonized *A. baumannii* is prone to biofilm formation on hospital equipment such as PICC, and biofilm formation has become a major pathogenic feature of *A. baumannii* among all virulence determinants.[10,11] Biofilm

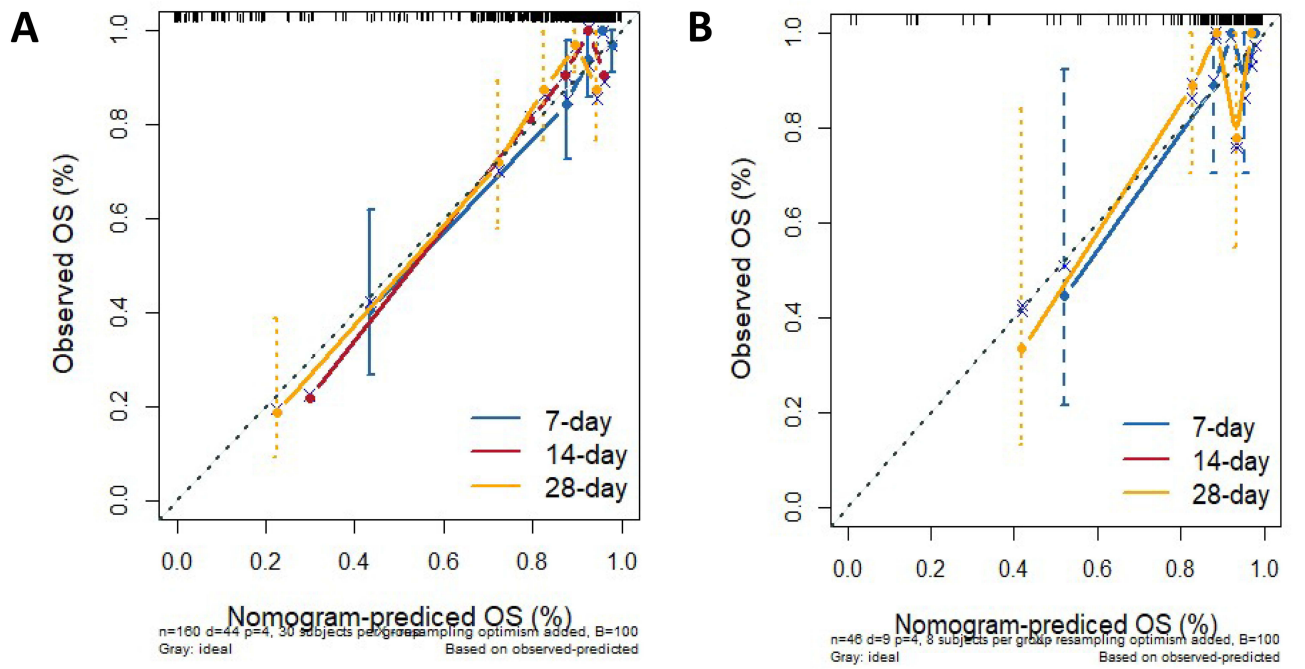

Figure 5 (**A**) Different time calibration curves for the training cohort; (**B**) Calibration curves for different time points in the test cohort.

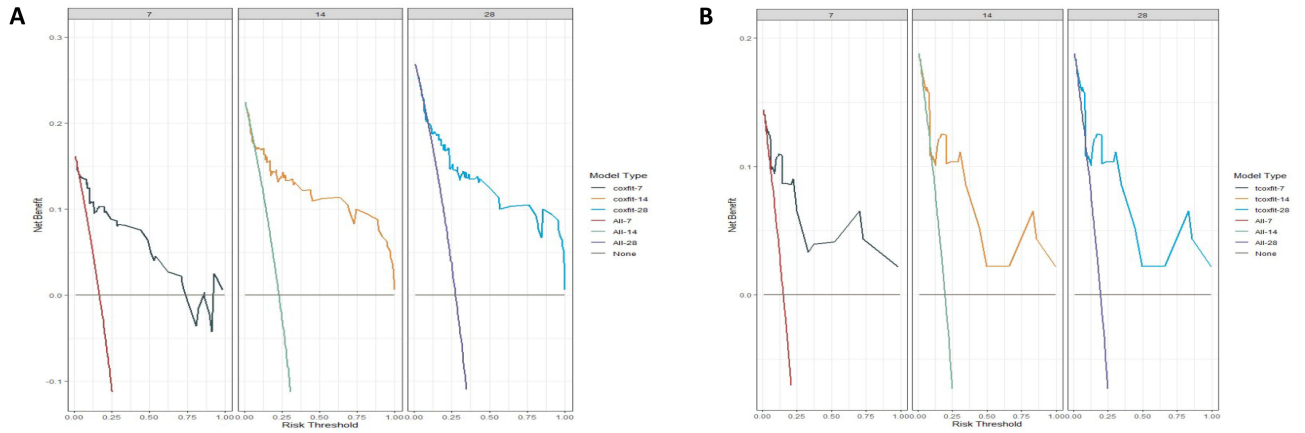

Figure 6 (**A**) DCA curves of the training cohort at different time points; (**B**) DCA curves of the test cohort at different time points.

formation not only improves microbial drug resistance but also enhances the expression of important virulence factors, such as biofilm-associated proteins[12], outer membrane proteins,[13,14] and pili Csu proteins,[15] thus increasing the virulence of *A. baumannii*.

In this study, the NLR was an independent risk factor for mortality in patients with *A*.baumannii BSI. NLR is a newly proposed indicator of inflammation in recent years, which has been well validated for prognostic prediction of BSI in different populations, such as pediatric tumor patients,[16] Intensive Care Unit patients,[17] and elderly patients with oral cavity squamous cell carcinoma.[18] However, the prognostic prediction ability of NLR in A. baumannii BSI remains controversial. Ability remains controversial. Wei et al showed[19] that NLR had limited effectiveness in predicting mortality within 28 days in patients with A. baumannii bloodstream infections; in the present study, NLR was an independent risk factor for death in patients with A. baumannii BSI, but the prognostic accuracy of NLR (AUC = 0.52) for 28-day all-cause mortality was poor, and it needs to be combined with other indices Prediction.

The study also showed that hypohemoglobinemia is strongly associated with death due to *A*.baumannii BSI. Hemoglobin is an intravascular macromolecule in the human circulation that serves as a carbon dioxide transporter, absorber, and transporter of antibiotics in the body, and hemoglobin performs these functions on the basis of its chelated iron to promote nonspecific immunity.[20] *A. baumannii* has a strong ability to extract iron from surrounding nutrients, and *A. baumannii* can activate ferrous iron uptake and regulate the secretory expression of SecA proteins and baumannoferritin, interfering with the synthesis and translocation of iron carriers and leading to impaired iron delivery to erythrocytes and reduced host iron availability, leading to inflammatory anemia.[21,22] Studies have shown that in patients with transfusion-dependent thalassemia, those with high serum ferritin levels are more likely to develop*A*.baumannii BSI.[23] On the other hand, hypohemoglobinemia leads to direct mechanisms of injury related to nitric oxide scavenging, exacerbating acid–base metabolic imbalances and worsening cardiac, pulmonary, and other multiorgan failures.[24,25] A large data study[26,27] showed that admission hemoglobin levels are closely associated with mortality after septic infection, with a 7% increase in the 28-day risk of death for every 1-unit increase in HGB when HGB is in the range of 12.8–20.7 g/dL. These two factors explain the increased mortality after *A*.baumannii BSI in patients with hypohemoglobinemia.

Thrombocytopenia was another important risk factor for death in patients with *A*.baumannii BSI in these studies. Patients with BSI often have thrombocytopenia, and reports have shown that more than half of BSI patients may develop thrombocytopenia.[28,29] Platelets play roles in the body, such as hemostasis and inflammation, and platelet activation is stimulated by bacteria or their toxins following infection in patients with sepsis, and activated platelets interact with leukocytes such as neutrophils and lymphocytes to exert anti-inflammatory effects.[30] Extensive activation of platelets, followed by aggregation with leukocytes, exacerbates the inflammatory response and leads to the formation of inflammatory thrombi, which in turn causes the coagulation cascade and even leads to DIC.[31–33] Increased platelet consumption and destruction following infection in BSI and septic patients leads to thrombocytopenia, which has been shown in several studies to be a risk factor for poor prognosis in BSI and septic patients.[28,34–36] On the other hand, a study in a population-based cohort of 683,421 patients showed that the use of antiplatelet agents in sepsis patients reduced the risk of death.[37] This study showed that patients in the nonsurviving group had significantly lower platelet counts than survivors did, which is consistent with previous findings.

The model developed in this study, as well as the nomogram, has multiple clinical implications, and this study has several advantages over previous studies. First, this study is novel in predicting the risk of death in patients with *A*. baumannii BSI. We used screening variables such as LASSO regression and developed a nomogram. Compared with traditional prognostic models, this approach is better at avoiding problems such as variable screening overfitting, and the nomogram can provide a quantitative tool for clinicians to predict the prognosis of patients with *A*.baumannii BSI more effectively and accurately, which can help to improve risk stratification. Second, the specificity and accuracy of the models established by screening were high. In this study, the AUC model was not less than 0.850, reflecting good predictive value, and the models performed well in terms of clinical decision-making benefit, especially in the first 7 days. Of the 206 patients, 53 died in the mortality group, with 64.2% (34/53) dying in the first 7 days, and the modeled first seven-day AUC was also significantly greater than those of the 14- and 28-day predictive scenarios. Such early deaths can be more directly attributed to the consequences of *A*.baumannii BSI and better reflect the mortality burden of BSI.[7] Third, the NLR, PLT, and HGB were all obtained from routine blood tests of the model variables screened in this study. The mortality rate of BSI is closely related to the economic situation of the region and is greater in developing countries such as sub-Saharan Africa, South Asia, East Asia and Southeast Asia, and the convenient and easy availability of the variables in this model can benefit a wide range of clinicians and patients.[38] In clinical practice, it is recommended to perform complete blood count along with blood cultures, and in the case of bloodstream infections caused by A. baumannii, timely analysis of NLR, PLT and HGB, and in the case of concomitant elevated NLR, low HGB levels, and low PLT, timely and symptomatic treatment is indicated to improve the prognosis.

Limitations of the Study

There are several limitations to our study. The study was based on single-center patients, which may not be representative of the wider population due to biases such as patient admission; in addition, due to the long period of case collection,

which is a retrospective study, potential unmeasured variables may not have been included in our model. As a next step, we are ready to externally validate our model in different patients, we will join hands with different healthcare institutions to jointly test complete blood count of patients who require blood cultures and follow them up, on the other hand, we will select suitable patients for timely correction of BSI caused by *A. baumannii* with respect to the NLR, HGB, PLT, therapeutic measures to further validate the reliability as well as accuracy of the model.

Conclusions

In this study, septic shock status, the NLR, HGB, and the PLT were found to be independent prognostic factors in patients with *A.*baumannii BSI. The main strength of our model is the use of variables that are readily available in any hospital setting. The developed nomogram accurately predicts OS in patients with *A.*baumannii BSI. As a next step, we will join hands with different hospitals to follow up the NLR, HGB, PLT indices in a timely manner to follow up the 28-day survival as well as the post-intervention treatment survival in patients with BSI caused by *A. baumannii*, so that we can provide valuable insights for the treatment of patients with *A. baumannii*-induced BSI.

Abbreviations

A. baumannii, Acinetobacter baumannii; BSI, bloodstream infection; LASSO, Least Absolute Shrinkage and Selection Operator; CRAb, carbapenem-resistant *Acinetobacter baumannii*; ICU, Intensive Care Unit; AUC, Area under the curve; ROC, Receiver Operating Characteristic; DCA, Decision curve analysis; OS, overall survival; PICC, peripherally inserted central catheter; WBC, White blood cell count; NLR, Neutrophil-to-lymphocyte ratio; HGB, Hemoglobin; PLT, Platelet count; AST, Aminotransferase; GLU, Blood glucose; CR, Creatinine.

Data Sharing Statement

Data are available upon reasonable request to the corresponding author.

Ethics and Consent to Participate Section

The study was approved by the Hospital Ethics Committee of Guangdong Provincial Second Hospital of Traditional Chinese Medicine and conducted according to the Declaration of Helsinki (Approved No. of ethics committee: Z202404-002-01). The ethics committee waived the requirement for informed consent because the study was retrospective in design.

Code Availability

The statistical software “R- version 4.3.1” was used.

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This paper has been uploaded to ResearchSquare as a preprint: https://www.researchsquare.com/article/rs-4487553/v1

Author Contributions

Conceived and designed: Xiaojun Li; Methodology: Xiaojun Li, Donghao Cai, Xinghui Huang; Collected the clinical data and literature review: Xiaojun Li, Chuangchuang Mei; Formal analysis and investigation: Xiaojun Li, Donghao Cai; Writing - review and editing: Xiaojun Li, Donghao Cai; Supervision: Xiaojun Li. All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

All the authors declare that they have no conflicts of interest.

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