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ORIGINAL RESEARCH

Clinical Prediction of Secondary Bloodstream Infections in Patients with Cerebral Infarction: A Nomogram-Driven Risk Assessment Model Based on LASSO Regression

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Purpose: To evaluate the impact of secondary bloodstream infections (BSI) on healthcare quality indicators in patients with cerebral infarction, and to develop a validated predictive model.

Methods: This study conducted a retrospective analysis of 7,698 distinct patients with cerebral infarction (2023) from a tertiary hospital in Guangzhou. Patients were categorized into two groups: BSI-negative (n=7,573) and BSI-positive (n=125). Healthcare quality indicators were compared using Mann–Whitney *U*-test. A predictive model was created using Least Absolute Shrinkage and Selection Operator (LASSO) regression, based on a 7:3 training-validation split. The model's performance was validated through the area under the Receiver Operating Characteristic curve (AUC), calibration curves, and decision curve analysis (DCA).

Results: Patients with BSI had significantly prolonged hospital stays (median of 17 days versus 11 days, p<0.001), higher costs (median of 34,859 yuan compared to 16,921 yuan, p<0.001), and increased adverse outcomes (34.4% versus 1.6%, p<0.001). The LASSO analysis identified four predictors: The following variables were found to have a statistically significant relationship to the occurrence of the primary complication: peripherally inserted central venous catheters (PICC) (odds ratio [OR] = 2.791, 95% confidence interval [CI] =1.514–5.148), use of ventilators(VA) (OR = 2.771, 95% CI=1.410–5.443), Indwelling urinary catheters-(CAU) (OR = 1.800, 95% CI= 0.990–3.276), and hypoalbuminemia (OR = 3.643, 95% CI=2.195–6.046).The nomogram demonstrated an AUC of 0.789 in the training set and 0.778 in the test set, indicating a satisfactory model fit across data sets. Good model fit based on Hosmer-Lemeshow*p*-values(Hosmer-Lemeshow*P*=0.338/0.170).DCA indicated a net clinical benefit at risk thresholds of 0–15%.

Conclusion: Secondary BSI in patients with cerebral infarction can seriously affect the quality of medical care.The developed nomogram functions as a pragmatic instrument for the preliminary identification of patients at high risk. It facilitates the implementation of targeted interventions, thereby reducing the incidence of BSI and enhancing patient outcomes.

Keywords: cerebral infarction, bloodstream infection, nomogram, healthcare quality

Introduction

According to the Global Burden of Disease survey, stroke is the second leading cause of death and the third leading cause of disability among noncommunicable diseases worldwide.[1] In 2021, the global prevalence of stroke patients reached 93.8 million, with an annual healthcare expenditure surpassing $890 billion. Cerebral infarction (ischemic stroke) accounted for 65.3% of all strokes, with more than 7.6 million new cases of cerebral infarction occur each year.[2] It is estimated that 77 million individuals are currently living with cerebral infarction and require long-term rehabilitation

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treatment in the later stage due to the characteristics of high disability after the onset of the disease. These individuals often require long-term hospitalization for rehabilitation and frequently need to use PICC, CAU and other invasive operations due to limited activities, aspiration and other reasons. These factors are considered high-risk factors for secondary BSI,[3–5] making patients with cerebral infarction a high-risk group for secondary BSI. The occurrence of BSI has been demonstrated to result in an escalation in the rate of ICU admission, prolonged hospital stay, and hospitalization costs, thereby exerting a deleterious effect on the quality of medical care and the prognosis of patients.[6,7.] While the diagnosis of BSI is primarily based on blood cultures, which require a longer time to report and may delay diagnosis, early diagnosis and early appropriate treatment have been reported to significantly improve the quality of care of patients.[8,9] However, at present, clinical prevention and control mainly relies on empirical evaluation, and there is a lack of accurate prediction tools, which leads to problems such as antibiotic abuse or lagging intervention.

In recent years, the application of machine learning technology in medical prediction models has significantly enhanced the ability to assess the risk of complex diseases. LASSO regression, also known as least absolute shrinkage and selection operator regression, is a type of machine learning model that is employed for the purpose of variable selection. LASSO regression is a regularization method that achieves variable screening and dimensionality reduction through L1 penalty terms, making it particularly suitable for addressing collinearity in high-dimensional data. This method has been successfully applied in various fields, such as infection risk analysis and BSI prognosis, demonstrating its value in clinical decision-making.[10,11] Nomograms offena visual representation of predictive models, facilitating interpretation and application in clinical practice. They have emerged as a significant tool for predicting clinical outcomes across a range of diseases, including stroke.[12] Conversely, this study utilized big data and analysis of big data and machine learning analysis statistics of patients with cerebral infarction BSI, in order to provide points for the clinical practice of cerebral infarction infection. The study collected the cerebral infarction data from a tertiary traditional Chinese medicine hospital in Guangzhou in 2023. The objective of this study is to investigate the influence of BSI on the quality of medical care for patients with cerebral infarction. In addition, the study aims to develop a prediction model using LASSO regression, with the goal of providing a tool for the early clinical identification of high-risk groups.

Objects and Methods

Study Design

A total of 11,802 inpatient non-duplicate admissions with a diagnosis of cerebral infarction from January–December 2023 were collected. A total of 7,698 inpatients with cerebral infarction were removed from duplicate admissions and screened according to BSI diagnostic criteria. If the patient has had multiple isolations of bacteria from blood cultures, the data from the first positive should be taken.The diagnostic criteria for BSI are as follows:

1. Meet the clinical diagnostic requirements for bloodstream infection: fever >38°C or hypothermia <36°C, which may be accompanied by chills, and combined with one of the following: invasive portals or migratory foci; systemic symptoms of toxicity without obvious foci of infection; rash or haemorrhagic spots, liver and spleen enlargement, and neutrophilia in the blood with a leftward shift of the nucleus, which can be explained by no other reason; systolic blood pressure lower than 12 kPa (90 mmHg), the or a decrease of more than 5.3kPa (40mmHg) from the original systolic blood pressure.

2. Isolation of pathogenic microorganisms by blood culture. If common skin organisms are isolated, such as coagulase-negative staphylococci and propionibacteria, it is necessary to collect blood at different times and have two or more positive cultures.

The patients were categorized into two groups based on the presence or absence of secondary BSI: the negative group (n=7,573) and the positive group (n=125). This study received approval from the Hospital Ethics Committee (Ethics Review Opinion No.: Z202404-002-01). The specific flow of the study is illustrated in Figure 1.

Data Collection

Information regarding patients' blood cultures and other indicators of BSI should be collected through the inspection information system. Utilize the hospital medical record system to gather data on the number of days of hospitalization,

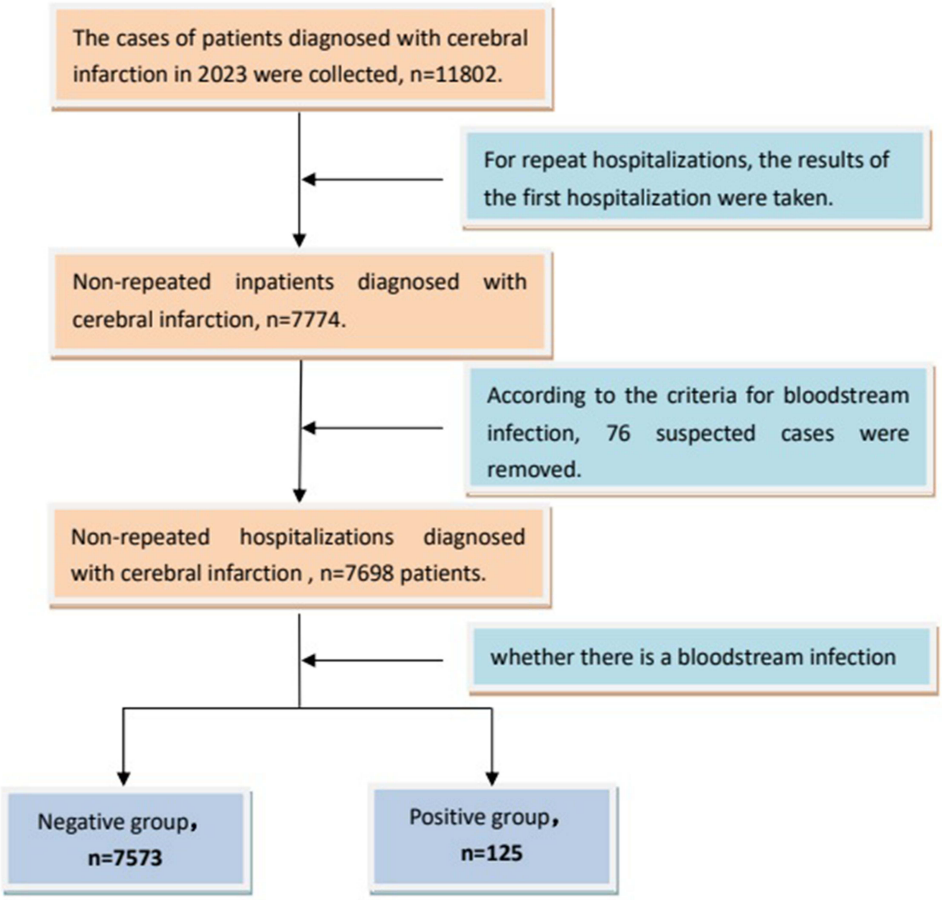

Figure 1 Study design.

medical expenses, and patient discharge status. The nosocomial infection surveillance system was employed to determine whether patients in the negative group were hospitalized during their stay, and whether patients in the positive group underwent invasive procedures such as PICC, VA, CAU prior to the diagnosis of BSI. The hospital medical record system also collects demographic data, including patients' age and gender, as well as information on comorbidities such as respiratory failure, pneumonia, coronary heart disease, hypertension, cardiac insufficiency, liver insufficiency, gallstones, urinary tract infections, diabetes, anemia, hypoproteinemia, electrolyte imbalances, and other underlying conditions. The impact of secondary BSI on the quality of medical care for patients with cerebral infarction was assessed using indicators such as patient discharge outcomes, hospitalization costs, and average length of stay. The discharge status of patients was documented on the first page of the medical record, where death and discharge without a physician's order were classified as adverse outcomes. Conversely, discharge by physician's order, transfer by physician's order, and transfer to a community health service organization or township health center were considered favorable outcomes.

Data Analysis

Categorical data were expressed as n (%), and the chi-square test was used for comparisons between groups. For continuous data sets that conform to a normal distribution, the mean ± standard deviation is reported, and the *t*-test is employed for group comparisons. Non-normally distributed data are presented as median (P25-P75), and the Mann–Whitney *U*-test is used for comparisons between groups. The patient data were randomly assigned in a 7:3 ratio, with the data divided into a training set and a validation set. The screening of variables was conducted using LASSO regression in the training set, and a model along with a prediction nomogram was constructed based on the LASSO regression results.

The performance of the model was evaluated using the AUC, calibration curve, and DCA. Statistical analysis was conducted using R software (version 4.3.1), with $p < 0.05$ considered statistically significant.

Results

Impact of Secondary BSI on the Quality of Medical Care of Patients

Given to the presence of secondary BSI, a univariate analysis was conducted on the outcomes, hospitalization costs, and length of hospital stay for the two groups. The findings of the study indicated that the hospitalization costs, length of stay, and number of patients experiencing adverse outcomes after secondary BSI in the positive group were significantly higher than those in the negative group, with all P values being less than 0.001. See Table 1.

Results of One-Way Analysis of Secondary BSI in Patients with Cerebral Infarction

The results showed that in comparison with the negative group, patients with cerebral infarction were more likely to have bloodstream infections due to increased age, use of VA, PICC, CAU, and complications such as combined respiratory failure, pneumonia, and hypoproteinemia (Table 2).

Table 1 Analysis of the Medical Quality of Patients with Secondary Bloodstream Infection

Characteristic	N, N= 7698	Negative Group, N =7573	Positive Group, N =125	statistic[a]	p-value
Adverse outcomes{n (%)}	162 (2.1)	119 (1.6)	43 (34.4)	627.452	< 0.001
Hospitalization costs {Median (P25,P75)}	16999.75 (12468.46, 26331.84)	16921.81 (12410.39, 25976.02)	34859.42 (19886.28, 66052.46)	10.260	< 0.001
Days in hospital {Median (P25,P75)}	11 (7, 15)	11 (7, 15)	17 (12, 24)	8.037	< 0.001

Notes: [a]Mann–Whitney *U*-test.

Table 2 Results of One-Way Analysis of Secondary BSI in Patients with Cerebral Infarction

Characteristic	N, N= 7698	Negative Group, N = 7573	Positive Group, N = 125	Statistic[a]	*p*-value
Age {Median (P25,P75)}	71 (61, 80)	71 (61, 80)	76(69, 85)	5.557	<0.001
Male {n (%)}	4545 (59.0)	4470 (59.0)	75 (60.0)	0.048	0.826
Invasive procedures					
VA{n (%)}	157 (2.0)	137 (1.8)	20 (16.0)	116.95	<0.001
PICC{n (%)}	1170 (15.2)	1099 (14.5)	71 (56.8)	170.617	<0.001
CAU{n (%)}	1549 (20.1)	1475 (19.5)	74 (59.2)	120.721	<0.001
Combined with					
Respiratory failure {n (%)}	267 (3.5)	248 (3.3)	19 (15.2)	52.231	<0.001
Pneumonia {n (%)}	2464 (32.0)	2380 (31.4)	84 (67.2)	72.307	<0.001
Coronary heart disease {n (%)}	1724 (22.4)	1685 (22.3)	39 (31.2)	5.667	0.017
Hypertension {n (%)}	5789 (75.2)	5691 (75.1)	98 (78.4)	0.697	0.404
Cardiac insufficiency {n (%)}	873 (11.3)	838 (11.1)	35 (28.0)	35.073	<0.001
Liver insufficiency {n (%)}	1797 (23.3)	1770 (23.4)	27 (21.6)	0.216	0.642
Gallstones {n (%)}	594 (7.7)	571 (7.5)	23 (18.4)	20.367	<0.001
Urinary tract infection{n (%)}	544 (7.1)	515 (6.8)	29 (23.2)	50.358	<0.001
Diabetes {n (%)}	3016 (39.2)	2955 (39.0)	61 (48.8)	4.936	0.026
Anemia {n (%)}	1324 (17.2)	1284 (17.0)	40 (32.0)	19.545	<0.001
Hypoproteinemia {n (%)}	816 (10.6)	762 (10.1)	54 (43.2)	142.496	<0.001
Electrolyte imbalance {n (%)}	965 (12.5)	932 (12.3)	33 (26.4)	22.276	<0.001

Notes: [a]Mann–Whitney *U*-test; Pearson's Chi-squared test; Fisher's exact test;
Abbreviations: VA, Ventilators; PICC, Peripherally Inserted Central Venous Catheters; CAU, urinary catheter.

Clinical Characteristics of Patients

The data were randomly assigned in a 7:3 ratio and divided into a training set (n=5,388) and a test set (n=2,310). The median age for both datasets was 71 years (range: 61 to 80), with no significant difference observed (P = 0.774). The gender distribution in the two datasets was found to be similar, with males comprising 59.3% of the training set and 58.4% of the test set (P = 0.456). The distribution of clinical variables, including the utilization of invasive procedures such as PICC and the presence or absence of underlying medical conditions like pneumonia, diabetes, and hypertension, were proportionally distributed between the groups, with no significant differences observed (P values ranged from 0.054 to 0.940). A thorough examination of the baseline characteristics reveals that the training and test sets are distributed equally, thereby validating the validity of subsequent predictive analyses.Refer to Table 3.

LASSO Regression for Variable Screening

In the construction of the LASSO regression model, all variables were given full consideration, including age, gender, the use of invasive procedures such as PICC, the presence of pneumonia, diabetes, hypertension, and other underlying conditions. The model was selected based on cross-validation error, specifically within one standard error of the minimum value. The final model incorporates four key variables: the utilization of VA, PICC, CAU and the presence of hypoproteinemia. The coefficient profile and cross-validation error plot for the LASSO regression model are presented in Figure 2.

Multivariate Regression Results

The utilization of VA, PICC, hypoproteinemia, and CAU were incorporated into the multivariate regression analysis. The results indicated that hypoproteinemia, the concomitant use of PICC, and the utilization of VA were independent risk factors for secondary BSI in patients with cerebral infarction (P< 0.05). See Table 4.

Table 3 Patient Demographics and Baseline Characteristics

Characteristic	N, N = 7698	Cohort		statistic[a]	p-value
		Training Cohort, N = 5,388	Test Cohort, N = 2,310		
Age {Median (P25,P75)}	71 (61, 80)	71 (61, 80)	71 (61, 80)	0.063	0.950
Male {n (%)}	4545 (59.0)	5195 (59.3)	1,350 (58.4)	0.456	0.499
Invasive procedures					
VA{n (%)}	157 (2.0)	109 (2.0)	48 (2.1)	0.005	0.946
PICC{n (%)}	1170 (15.2)	833 (15.5)	337 (14.6)	0.886	0.346
CAU{n (%)}	1549 (20.1)	1090 (20.2)	459 (19.9)	0.109	0.741
Combined with					
Respiratory failure {n (%)}	267 (3.5)	192 (3.6)	75 (3.2)	0.394	0.530
Pneumonia {n (%)}	2464 (32.0)	1703 (31.6)	761 (32.9)	1.266	0.260
Coronary heart disease {n (%)}	1724 (22.4)	1222 (22.7)	502 (21.7)	0.783	0.376
Hypertension {n (%)}	5789 (75.2)	4053 (75.2)	1736 (75.2)	0.001	0.970
Cardiac insufficiency {n (%)}	873 (11.3)	598 (11.1)	275 (11.9)	0.966	0.326
Liver insufficiency {n (%)}	1797 (23.3)	1241 (23.0)	556 (24.1)	0.914	0.339
Gallstones {n (%)}	594 (7.7)	419 (7.8)	175 (7.6)	0.066	0.798
Urinary tract infection {n (%)}	544 (7.1)	378 (7.0)	166 (7.2)	0.048	0.827
Diabetes {n (%)}	3016 (39.2)	2117 (39.3)	899 (38.9)	0.080	0.778
Anemia {n (%)}	1324 (17.2)	937 (17.4)	387 (16.8)	0.417	0.518
Hypoproteinemia {n (%)}	816 (10.6)	585 (10.9)	231 (10.0)	1.166	0.280
Electrolyte imbalance {n (%)}	965 (12.5)	671 (12.5)	294 (12.7)	0.087	0.768

Notes: a Mann–Whitney *U*-test; Pearson's Chi-squared test; Fisher's exact test;
Abbreviations: VA,Ventilators; PICC, Peripherally Inserted Central Venous Catheters; CAU, urinary catheter.

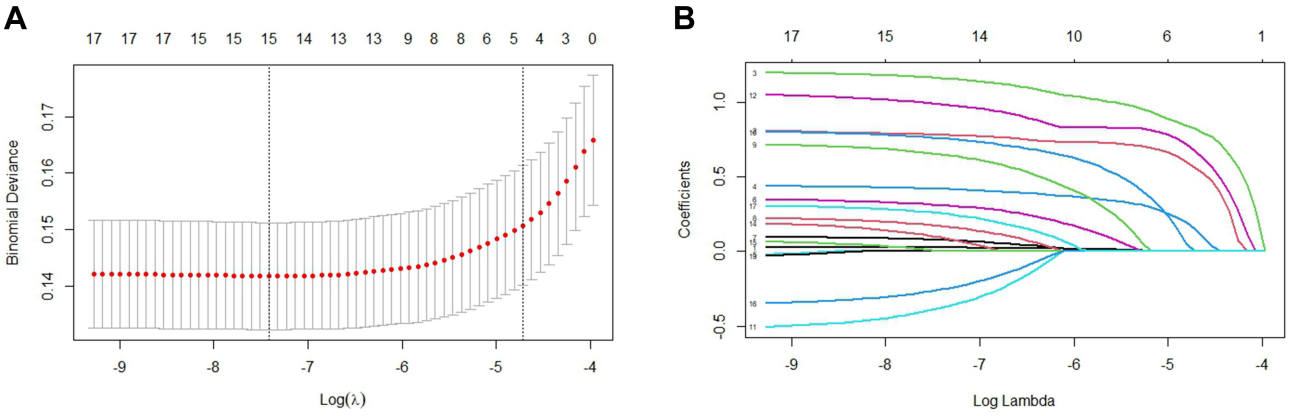

Figure 2 (**A**) LASSO regression coefficient profile; (**B**) LASSO regression cross-validation error plot.

Constructing a Nomogram

The final logistic model included four independent predictors (use of PICC, CAU, VA, and hypoproteinemia) and was developed into a user-friendly nomogram. Using a combination of VA, PICC, CAU, and hypoproteinemia increased the overall risk score for secondary BSI in patients with cerebral infarction (Figure 3).

Performance Verification of the Nomogram Prediction Model

Repeated k-fold cross-validation of the model (K = 5, repetition = 3), the model Root Mean Square Error (RMSE) is 0.124 and Mean Absolute Error (MAE) is 0.031, the RMSE and MAE values are small, the average error between the model's prediction results and the actual observations is small, and both the model fit and prediction The model fit and prediction accuracy are good. The AUC of the model and each variable was utilized to assess the discrimination capability of the prediction model. In the training set, the AUC value of the model was 0.789, with the AUC value for the PICC being the highest at 0.713. In the test set, the AUC value of the model was 0.778, and the AUC value for PICC was again the highest at 0.709 (Figure 4).

The *p*-values from the Hosmer-Lemeshow test for the training set and the test set were 0.338 and 0.170, respectively, indicating that the model fits well. The prediction model utilizes 500 self-samplings to generate calibration curves for both the training set and the test set, thereby enabling an evaluation of the model's calibration ability. The calibration curve reveals a strong alignment between the acceptable and ideal curves, suggesting a high degree of similarity in their trends. In addition, the calibration curve ascends at a 45-degree angle along the actual probability and predicted probability axes. This finding indicates that the prediction model demonstrates adequate calibration capability in both the training and test sets (see Figure 5).

The DCA was utilized to assess the net benefit of intervention in high-risk patients. The decision curve indicated a net benefit for intervening in patients with risk factors within the 0% to 15% range of the model, as illustrated in Figure 6.

Table 4 Multivariate Logistic Regression Results for the Training Set

variable	β	S.E	Wals	p-value	OR[a]	95% CI[b]
VA	1.019	0.345	8.751	0.003	2.771	1.410–5.443
PICC	1.027	0.312	10.808	0.001	2.791	1.514–5.148
CAU	0.588	0.305	3.708	0.054	1.800	0.990–3.276
Hypoproteinemia	1.293	0.258	25.012	<0.001	3.643	2.195–6.046

Notes: [a]OR, Odds Ratio; [b]CI, Confidence Interval.
Abbreviations: VA, Ventilators; PICC, Peripherally Inserted Central Venous Catheters; CAU, urinary catheter.

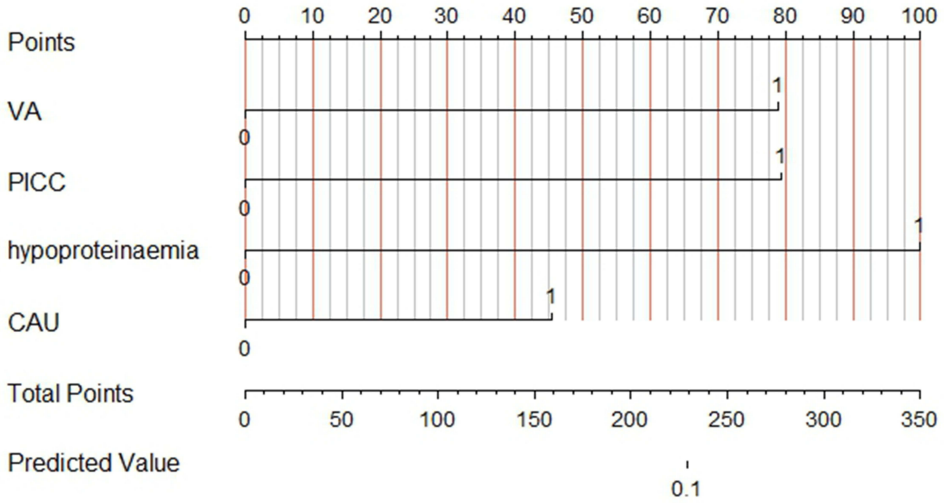

Figure 3 Nomogram prediction model.

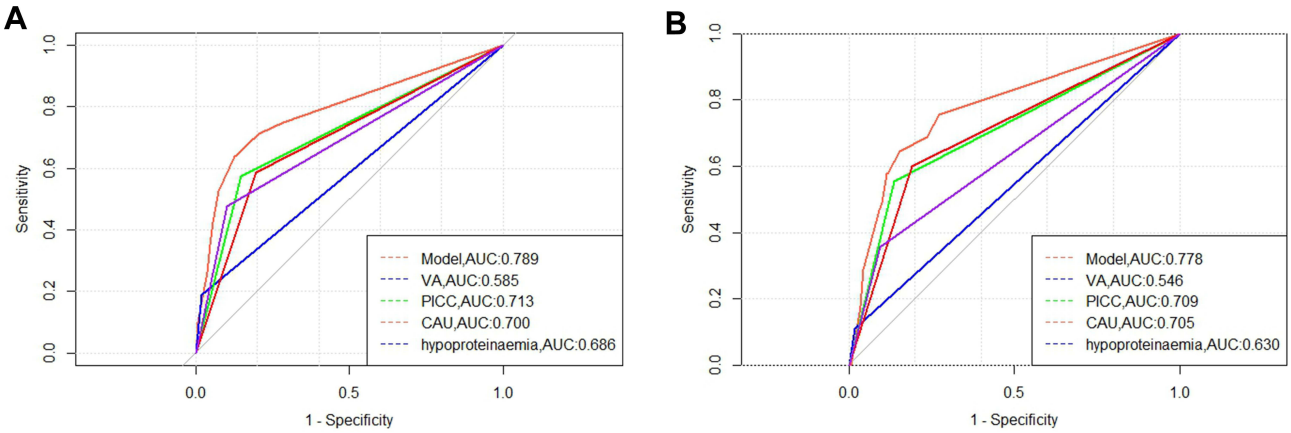

Figure 4 (**A**) The model in the training set and the AUC value of each variable; (**B**) AUC values of the model and each variable in the test set.

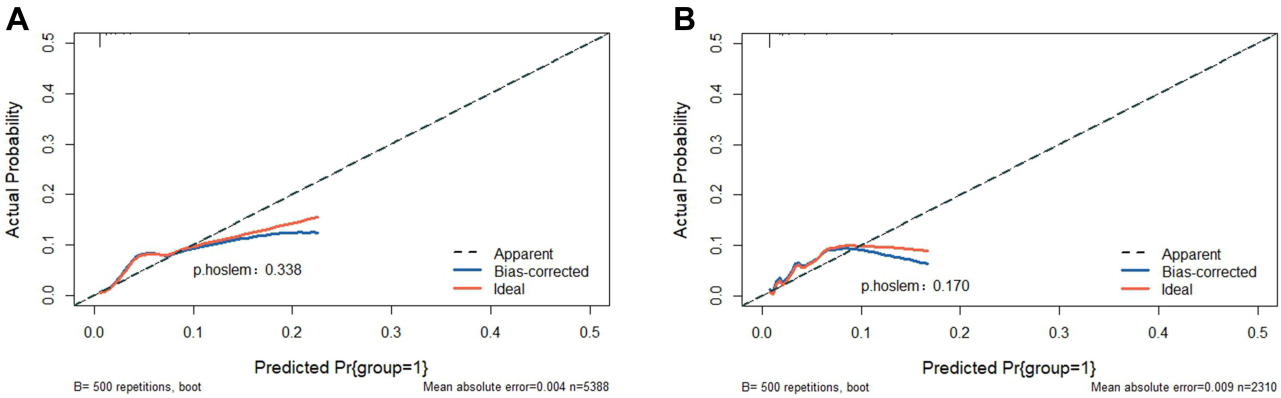

Figure 5 (**A**) Training set calibration curves; (**B**) Test set calibration curves.

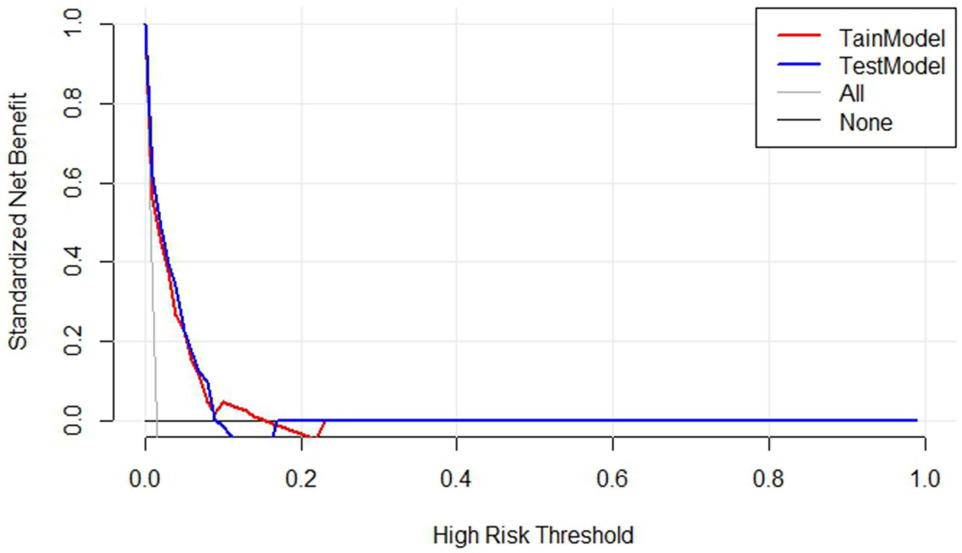

Figure 6 Clinical decision curves of the model.

Discussion

In this study, we sought to elucidate the disparities in hospital stay duration, hospitalization costs, and discharge outcomes between two groups of 7,698 hospitalized patients with cerebral infarction, contingent upon the presence or absence of BSI. The results indicated that patients in the BSI-positive group experienced prolonged hospital stays, elevated medical expenditures, and a higher frequency of adverse outcomes. As demonstrated by George et al,[13] demonstrated that secondary infections in patients with cerebral infarction have been shown to result in prolonged hospital stays, increased healthcare costs, and an elevated probability of unfavorable prognoses. In China, the total annual expenditure for cerebral infarction exceeds $201.17 billion. As the prevalence of comorbidities rises, so do the associated medical expenses for patients. As indicated by the findings of HE et al,[14] there is a notable correlation between the increase in comorbidities associated with cerebral infarction and the rise in hospitalization costs. This phenomenon has a substantial impact on the quality of medical care.

In this study, a nomogram was developed and validated for predicting BSI in 7,698 hospitalized patients with cerebral infarction. The development of this nomogram was predicated on the presence or absence of BSI, and it employed LASSO regression to identify infection risk factors. In the univariate analysis of infection, a multitude of statistically significant variables were identified; however, an excess of variables can lead to overfitting of the model. It has been demonstrated that the LASSO regression method possesses superior discriminatory capability for model screening when compared to conventional methods, such as stepwise regression. Furthermore, LASSO imposes penalties on the regression coefficients, thereby enhancing the generalizability of the developed algorithm to external datasets.[10] In the present study, the AUC of the model constructed using LASSO regression was 0.778–0.789, the RMSE was 0.124, the MAE was 0.031, and the model demonstrated good accuracy and prediction precision.

The initial predictor variables encompassed the concomitant utilization of PICC, VA, CAU, and hypoproteinemia. For patients suffering from cerebral infarction who require long-term rehabilitation and have compromised immunity, BSI is highly insidious condition. It is difficult to diagnose, and the prognosis after diagnosis is poor. When the patient has symptoms of BSI such as fever or chills, clinical medical staff can evaluate the risk of BSI in patients with cerebral infarction through well-differentiated model indicators in a few minutes or less. This facilitates the ability to make clinical decisions in a timely manner according to the risk of BSI.

In the model, the utilization of a PICC, VA, CAU and serum albumin level were identified as the pivotal variables influencing whether patients with cerebral infarction continued to exhibit bacteremia. The increased utilization of invasive procedures such as PICC,[15] CAU[16] and VA[17,18] has been observed to potentially compromise mucosal barrier,

thereby increasing the risk of bacterial penetration into the bloodstream. In the context of mechanical ventilation, endotracheal intubation, and direct incision of the mucosal barrier of the upper respiratory tract, there is a disruption that allows oropharyngeal bacteria to invade the lower respiratory tract. This invasion may occur through damaged blood vessels, resulting in the bacteria entering the blood circulation. The long-term indwelling of the CAU can result in the formation of a biofilm, which can serve as a persistent source of infection for pathogens. If the internal tubing and humidifier of the ventilator are not meticulously sterilized, they are susceptible to bacterial growth, which can occur directly through the airflow and subsequently enter the patient's airway, spreading to the bloodstream and increasing the risk of bacteremia.[17,18] Serum albumin has been demonstrated to be closely related to immunity, and low albumin levels have been shown to lead to decreased complement activity, decreased antibody synthesis, and decreased plasma colloidal osmotic pressure, which can result in edema. This, in turn, can affect local tissue barrier function and weaken the body's ability to resist infection, thereby increasing the risk of BSI. Furthermore, albumin decline has been identified as a risk factor for BSI.[19,20]

Patients with cerebral infarction are susceptible to hypoproteinemia due to their underlying conditions, nerve damage, and other related factors. These patients frequently necessitate more invasive procedures, including PICC, VA and CAU which renders them a high-risk category for BSI. For patients with cerebral infarction who are at an elevated risk of such infections, the likelihood of infection can be significantly reduced through strict management of invasive procedures. This includes the avoidance of unnecessary catheter placement, the conducting daily assessments to determine the appropriate timing for extubation, and the minimization of the duration of catheter placement.[21,22] The implementation of comprehensive preventive and control measures, including rigorous hand hygiene prior to contact with catheters, the utilization of sterile gloves, and the employment of isolation gowns during surgical procedures, has been demonstrated to reduce the incidence of nosocomial infections in patients.[23–25] This, in turn, has the potential to enhance the quality of medical care for patients. The accurate identification of the BSI secondary to cerebral infarction is paramount. Timely intervention, aimed at reducing its comorbidities, is essential. Furthermore, it is crucial to assist relevant departments in formulating more effective medical insurance policies and health service guidelines. This, in turn, will ultimately reduce the medical costs of cerebral infarction patients, improve their medical quality of life, and facilitate the rational allocation of dedicated health resources.

Study limitations

In this study, we systematically evaluated the impact of BSI on the medical quality of life of patients with cerebral infarction and established a predictive model for secondary BSI in this population with high interpretability. However, there are several limitations to consider: first, as a single-center retrospective study, patient selection and other factors may introduce selection bias. In addition, the available research data are insufficient and require validation in a larger cohort. Future prospective studies should be conducted in conjunction with an exploration of the underlying pathogenic mechanisms, and efforts should be made to expand the research to multicenter validation to further optimize the performance of the model.

Conclusions

The nomogram developed in this study provides an innovative tool for accurate prevention and control. It is expected to improve the quality of medical care for patients with cerebral infarction by integrating clinical risk assessment with infection prevention strategies. In the next phase, we will further implement the model in clinical practice and conduct prospective studies to evaluate the impact of preventive measures on BSI in patients with cerebral infarction, thereby providing more valuable insights.

Abbreviations

BSI, bloodstream infection; LASSO, Least Absolute Shrinkage and Selection;Operator; AUC, Area under the curve; ROC, Receiver Operating Characteristic; DCA, Decision curve analysis; PICC, peripherally inserted central catheter; VA,Ventilators; CAU,urinary catheter.

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. The data of 7,698 patients used in the study were anonymised by removing the patients' personal information during the statistical process, and we confirm that the patient data were kept confidential in the study data provided.

Code Availability

The statistical software "R-version 4.3.1" was used.

Disclosure

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

References

1. GBD. 2021 stroke risk factor collaborators. global, regional, and national burden of stroke and its risk factors, 1990-2021: a systematic analysis for the global burden of disease study 2021. *Lancet Neurol*. 2024;23(10):973–1003. doi:10.1016/S1474-4422(24)00369-7.
2. Feigin VL, Brainin M, Norrving B, et al. World stroke organization: global stroke fact sheet 2025. *Int J Stroke*. 2025;20(2):132–144. doi:10.1177/17474930241308142
3. Cui Y, Yi C, Zhang C, et al. Risk factors for bloodstream infection among patients admitted to an intensive care unit of a tertiary hospital of Shanghai, China. *Sci Rep*. 2024;14:12765. doi:10.1038/s41598-024-63594-8
4. Alqalah TA. Mitigating risks in central line-associated bloodstream infection: a comprehensive insight into critical care nurses' knowledge, attitudes, barriers, and compliance. *BMC Nurs*. 2024;23:497. doi:10.1186/s12912-024-02168-5
5. Bicudo D, Batista R, Furtado GH, Sola A, Medeiros EA. Risk factors for catheter-related bloodstream infection: a prospective multicenter study in Brazilian intensive care units. *Braz J Infect Dis*. 2011;15(4):328–331. doi:10.1016/S1413-8670(11)70200-8
6. Goto M, Al-Hasan MN. Overall burden of bloodstream infection and nosocomial bloodstream infection in North America and Europe. *Clin Microbiol Infec*. 2013;19(6):501–509. doi:10.1111/1469-0691.12195
7. Zha L, Li S, Guo J, et al. Global and regional burden of bloodstream infections caused by carbapenem-resistant Gram-negative bacteria in 2019: a systematic analysis from the MICROBE database. *Int J Infect Dis*. 2023;153:107769. doi:10.1016/j.ijid.2024.107769
8. Wang J, Zhang J, Wu ZH, et al. Clinical characteristics and prognosis analysis of acinetobacter baumannii bloodstream infection based on propensity matching. *Infect Drug Resist*. 2022;Volume 15:6963–6974. doi:10.2147/IDR.S387898
9. Papadimitriou OM, Fligou F, Spiliopoulou A, et al. Risk factors and predictors of carbapenem-resistant Pseudomonas aeruginosa and Acinetobacter baumannii mortality in critically ill bacteraemic patients over a 6-year period (2010-15): antibiotics do matter. *J Med MicrobioL*. 2017;66(8):1092–1101. doi:10.1099/jmm.0.000538
10. DifazioRL S, Vessey JA, Vessey JA, et al. Comparison of two modeling approaches for the identification of predictors of complications in children with cerebral palsy following spine surgery. *BMC Med Res Methodol*. 2023;24(1):236. doi:10.1186/s12874-024-02360-w
11. Li X, Cai D, Mei C, Huang X. Construction and validation of a predictive model for mortality risk in patients with *acinetobacter baumannii* bloodstream infection. *Infect Drug Resist*. 2024;Volume 17:5247–5260. doi:10.2147/IDR.S491537
12. Zhang Z, Mw K, Zhang Z. Drawing nomograms with R: applications to categorical outcome and survival data. *Annals of Translational Medicine*. 2020;8(6):402. doi:10.21037/atm.2020.02.133
13. George AJ, Boehme AK, Siegler JE, et al. Hospital-acquired infection underlies poor functional outcome in patients with prolonged length of stay. *ISRN Stroke*. 2013;2013:312348. doi:10.1155/2013/312348
14. He Y, Chen S, Chen Y. Analysis of hospitalization costs in patients suffering from cerebral infarction along with varied comorbidities. *Int J Environ Res Public Health*. 2022;19(22):15053. doi:10.3390/ijerph192215053
15. Rickard CM, Marsh NM, Larsen EN, et al. Effect of infusion set replacement intervals on catheter-related bloodstream infections (RSVP): a randomised, controlled, equivalence (central venous access device)-non-inferiority (peripheral arterial catheter) trial. *Lancet*. 2021;397(10283):1447–1458. doi:10.1016/S0140-6736(21)00351-2
16. Djeribi R, Bouchloukh W, Jouenne T, Menaa B. Characterization of bacterial biofilms formed on urinary catheters. *Am J Infect Control*. 2012;40(9):854–859. doi:10.1016/j.ajic.2011.10.009
17. Mantzarlis K, Deskata K, Papaspyrou D, et al. Incidence and risk factors for blood stream infection in mechanically ventilated COVID-19 patients. *Antibiotics*. 2022;11(8):1053. doi:10.3390/antibiotics11081053
18. Jones DJ, Munro CL. Oral care and the risk of bloodstream infections in mechanically ventilated adults: a review. *Intensive Crit Care Nurs*. 2008;24(3):152–161. doi:10.1016/j.iccn.2008.01.004
19. Pai KC, Wang MS, Chen YF, et al. An artificial intelligence approach to bloodstream infections prediction. *J Clin Med*. 2021;10(13):2901. doi:10.3390/jcm10132901
20. Altın N, Hekimoğlu CH, Unver Ulusoy T, et al. Gram-negative bloodstream infections in healthcare: the relationship between antibiotic resistance, mortality, and novel serological biomarker. *Cureus*. 2024;16(4):e57720. doi:10.7759/cureus.57720

21. Laan BJ, Maaskant JM, Spijkerman IJB, et al. De-implementation strategy to reduce inappropriate use of intravenous and urinary catheters (RICAT): a multicentre, prospective, interrupted time-series and before and after study*s*. *Lancet Infect Dis*. 2020;20(7):864–872. doi:10.1016/S1473-3099(19)30709-1
22. Mermel LA, Farr BM, Sherertz RJ, et al. Guidelines for the management of intravascular catheter-related infections. *Clin Infect Dis*. 2001;32(9):1249–1272. doi:10.1086/320001
23. Flores-Mireles A, Hreha TN, Hunstad DA. Pathophysiology, treatment, and prevention of catheter-associated urinary tract infection. *Top Spinal Cord InjRehabil*. 2019;25(3):228–240. doi:10.1310/sci2503-228
24. Buetti N, Timsit JF. Management and prevention of central venous catheter-related infections in the ICU. *Semin Respir Crit Care M*. 2019;40(4):508–523. doi:10.1055/s-0039-1693705
25. Weinberger J, Cocoros N, Klompas M. Ventilator-associated events: epidemiology, sRisk factors, and prevention. *Infect Dis Clin North Am*. 2021;35(4):871–899. doi:10.1016/j.idc.2021.07.005

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