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ORIGINAL RESEARCH

Clinical Characteristics and Prognosis Analysis of *Acinetobacter baumannii* Bloodstream Infection Based on Propensity Matching

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Purpose: In view of the fact that *Acinetobacter baumannii* bloodstream infection(BSI) is a great threat to human survival, early identification of the risk factors affecting prognosis will be of great benefit to the clinic.

Patients and Methods: A propensity score matching method was used to collect patients identified with *Acinetobacter baumannii* BSI from 2016 to 2020 from a reputable hospital in China.

Results: A total of 398 patients were considered. According to the 28-day prognosis, they were divided into the survival group 150 (37.7%) and the death group 248 (62.3%), and the prognosis was analyzed. Subsequently, Propensity score matching was adjusted for variables with p-values <O.2 in the baseline data, equalized differences in baseline, multivariate paired logistics regression analysis was performed on 63 matched patients and showed that patients with *Acinetobacter baumannii* BSI who had higher SOFA scores at the time of infection, with septic shock, or mechanical ventilation were more likely to be fatally hit within 28 days and had a poor prognosis.

Conclusion: The existence of drug resistance with *Acinetobacter baumannii* only leads to Inappropriate empirical antibiotic therapy, ultimately, Inappropriate empirical antibiotic therapy was the direct predictor of mortality.

Keywords: *Acinetobacter baumannii*, bloodstream infection, propensity score matching, prognosis, inappropriate empirical antibiotic therapy

Introduction

Acinetobacter baumannii is notorious for its ability to colonize hospital settings and the increase of multidrug-resistant bacteria.[1–3] It is also constantly attracting widespread attention worldwide.[4] An international cohort study by EUROBACT[5] showed that *Acinetobacter baumannii* was the most common pathogen of nosocomial bloodstream infection (BSI) in intensive care unit (ICU). In China, where *non-fermenting Gram-negative bacilli* causing BSI, *Acinetobacter baumannii* became the second most pathogenic bacterium after *Pseudomonas aeruginosa*.[6] According to reports, the mortality rate of *Acinetobacter baumannii* BSI ranges between 29% and 73%.[7–9] Therefore, exploring the clinical characteristics and risk factors for death in *Acinetobacter baumannii* BSI patients will be of great benefit to clinical work.

The risk factors of adverse outcomes of *Acinetobacter baumannii* BSI are constantly being explored, some studies have shown that excessive use of steroids before the occurrence of bacteremia and septic shock during hospitalization were significantly associated with the poor prognosis.[10] A multicenter study from five hospitals in South Korea showed that the severity of the patient's disease was essential factor affecting the prognosis of *Acinetobacter baumannii* BSI,[11] Son, et al[12] reported that the 30-day mortality of *Acinetobacter baumannii* BSI is inextricably linked to the nature of the infection source and source control, the severity of bacteremia, and inappropriate definitive

treatment. Unfortunately, the risk factors of death in patients with *Acinetobacter baumannii* BSI in other researchs remained inconsistent; the reasons may be as follows, the existence of the study population differences, failed to differentiate between *Acinetobacter baumannii* colonization or infection, could not to adjust for confounding factors such as disease severity and comorbidities, nonetheless, in order to achieve more accurate and precise results, it is necessary to recognize prognostic factors influencing *Acinetobacter baumannii* BSI by taking an improved method, it can effectively improve the survival rate and lighten the burden of disease with *Acinetobacter baumannii* BSI patients. Propensity score matching can effectively balance the baseline differences and reduce the influence of bias and confounding factors in the study. As studied by Joe Amoah,[13] propensity score analysis is generally more favorable than traditional regression analysis when estimating causal effects using observed data.

This study further explored the clinical characteristics of BSI, adjusted the confounding factors by using propensity score matching, and explored the factors influencing the 28-day mortality of *Acinetobacter baumannii* BSI patients. The study design is shown in Figure 1.
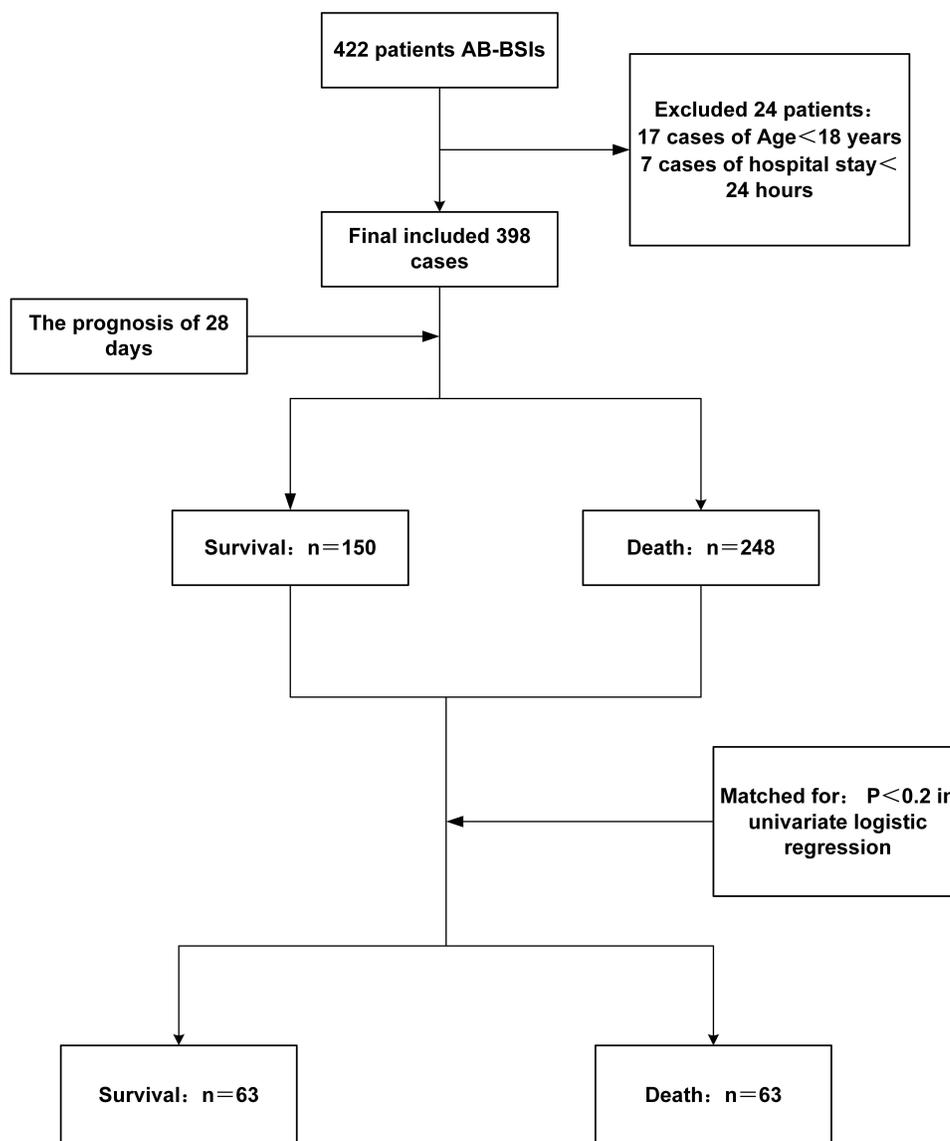

Figure 1 Study design of *Acinetobacter baumannii* BSI patients.

Materials and Methods

Study Subjects and Inclusion Criteria

The study was carried out in the first affiliated hospital of Zhengzhou University, Henan Province. This is a famous tertiary hospital in the province. The hospital was retrospectively analyzed for at least one blood culture (BC) positive for *Acinetobacter baumannii* BSI from 2016 to 2020, and simultaneously, met the diagnostic criteria for BSI as proposed by the CDC.[14] Only the first positive culture specimen were retained for patients with multiple bacteremia episodes. Patients were aged <18 years, and those discharged within 24 hours of admission were excluded. Patients with peripheral BC which were multiple- bacterial infections would not also not be noticed.

This study was approved by the Scientific Research and Clinical trial Ethics Committee of the first affiliated Hospital of Zhengzhou University (Code 2019-KY-330). Patient consent to participate was waived according to local Ethics Committee due to the retrospective and anonymous characteristics of the study. The study was conducted in accordance with the Declaration of Helsinki.

Variables and Definitions

Through the hospital database, we got the patient's demographics(gender, age), admitted to the department during BC, clinical parameters(hospital before, ICU before, hospital before infection onset ICU before infection onset). Any comorbidity(diabetes, hypertension, hypertension, cardiovascular disease, cardiopulmonary, resuscitation, malignancy, renal failure, pulmonary infection, respiratory failure). Invasive procedures before bacteremia(mechanical ventilation, surgery), results of drug sensitivity test, laboratory data(White Blood Cell Counts. Procalcitonin (PCT), C-Reactive Protein (CRP), and Lactic Acid (lac)), Severity of disease(APACHE II, SOFA, GCS, septic shock), Antimicrobial regimens before positive BC. Key data such as adverse events and outcomes, If necessary, they would be followed up by telephone to obtain out-of-hospital survival information. Made the clinical data of patients as complete as possible. What interested us was the prognosis after 28 days. The death group is defined as patients who died within 28 days (≤28) from the start of the BC collection day, and the survival group refers to patients who survived more than 28 days.

Inappropriate empirical antibiotic therapy is defined as no antibiotic of any sensitive class being given before a positive BC result according to the drug sensitivity test results. In this study, the duration of antibiotics included in the efficacy analysis ≥ 24 hours.

Multidrug resistance (MDR) is characterized by insensitivity to three or more antibiotics within the antibacterial spectrum. Extensive drug-resistance (XDR) is defined as insensitivity to almost all types of antibiotics except one or two types of antibiotics. Pandrug resistance (PDR) refers to that is insensitivity to all types of antimicrobials currently being used in clinical settings.[15]

Strain Identification and Drug Sensitivity Testing

Use of the VITEK 2 System (BioMérieux, CRaponne, France) for identification of strains in blood samples, Susceptibility Testing by Disk Diffusion, Minimum inhibitory concentration (MIC) was determined by agar dilution; the interpretation of drug sensitivity test results is based on the recommendations issued by the European Committee for antibiotic susceptibility testing (EUCAST).[16] It is worth mentioning that the results of drug sensitivity suggest that *Acinetobacter baumannii*, which is intermediately sensitive to antibiotics, is identified as drug-resistant.

Statistical Analysis

SPSS25.0(IBM Corp., Armonk, NY, USA) software was used for analysis. For continuous variables with normal distributions, the mean ± standard deviation (mean ± SD) was used, and for non-normal distributions, the median [interquartile range] (Median[IQR]). was used. Categorical variables were expressed as frequencies and percentages. The prognostic factors of *Acinetobacter baumannii* BSI 28-day mortality were screened by binomial Logistic regression, and the odds ratio and 95% confidence interval were calculated at the same time. Variables with P values < 0.05 in the univariate logistic analysis were included in the multivariable regression model, and we considered the results with P values <0.05 to be statistically significant.

Subsequently, the survival group was matched with the death group by using 1:1 matching for propensity score to reduce possible bias due to unbalanced baseline characteristics between the two groups, the variables of baseline data p value < 0.2 in univariate logistic regression were used as independent predictors to calculate propensity score, and the caliper value was set at 0.2. The 1: 1 nearest neighbor matching method was used to match each survival patient with the death patient separately. After matching propensity score, the matched samples were analyzed by univariate and multivariate paired logistics regression analysis. P < 0.05 was statistically significant. Furthermore, we evaluated the differences between the survival and the death group regarding inappropriate empiric therapy.

Results

Characteristics of the Study Population

This single-center retrospective study included 422 patients and excluded 24, of whom 17 were <18 years old and seven were discharged within 24 hours of admission. 398 eligible patients were considered. The majority were male patients 264 (66.3%), and the average age of 398 patients was 53.0 ±15.9 years old, the hospital stay ranged from 2 to 209 days, and 371 (93.2%) patients had at least one comorbidity. The most common were pulmonary infection 290 (72.9%) and respiratory failure 195 (49.0%). Up to 328 (82.4%) patients underwent invasive procedures before the onset of bacteremia. We found that *Acinetobacter baumannii* was detected in 316 patients (79.4%) during ICU hospitalization, and the median length of stay in ICU prior to infection onset was 6.0 days [3.0 12.0] days. In our population, 345 patients (86.7) were classified as *Carbapenem-resistant Acinetobacter baumannii* (CRAB). The SOFA score was 10.0 ± 5.4 on average for all patients. The demographic, clinical, and laboratory characteristics of the 398 participants are summarized in Table 1.

Risk Factors for 28-Day Mortality in Patients with *Acinetobacter baumannii* BSI

According to the 28-day prognosis, the patients were divided into the survival group (150 cases, 37.7%) and the death group (248 cases, 62.3%). During the 5-year study, the overall mortality rate was as high as 62.3%. Univariate analysis showed that the distribution of gender (P=0.913) and age (P=0.148) was similar between the survival group and the death group. Compared with the death group, the length of stay in the survival group was significantly longer (31.0 vs 15.0, P < 0.001), as shown in Table 2. Patients in the death group were more likely to have renal failure, pulmonary infection, respiratory failure, and so on; the differences were statistical significance. The most common comorbidity was pulmonary infection 209 (84.3%), and patients who received cardiopulmonary resuscitation (P < 0.001) or invasive procedures (P < 0.001) during hospitalization were at significantly increased risk of death. Comparing the drug resistance between the survival group and the death group, it was observed that the drug resistance rate of the death group to carbapenem was significantly higher than that of the survival group (P < 0.001). Most of the dead patients were distributed in ICU (91.5% vs 8.5%, P < 0.001). Univariate analysis identified laboratory indicators associated with 28-day mortality in *Acinetobacter baumannii* BSI, including PCT, CRP, and lac. in terms of disease severity, a higher APACHE score or SOFA score was a potential risk factor for 28-day mortality.

The factors with statistical significance in the univariate Logistic analysis were included in the multivariate Logistic regression analysis. The results were shown in Table 3. The prolongation of hospital stay is a protective factor for the 28-day mortality of *Acinetobacter baumannii* BSI, and the risk of mortality in patients undergone cardiopulmonary resuscitation in the hospital was 6.389 times higher than that in patients without cardiopulmonary resuscitation. Patients with renal failure were also an independent risk factor for death within 28 days of *Acinetobacter baumannii* BSI, consistent with univariate analysis, the Higher APACHE score was an independent risk factor for death.

Risk Factors for 28-Day Mortality in Patients with *Acinetobacter baumannii* BSI After a Propensity Scoring Match

Propensity score matching was adjusted for variables with P<0.2 in univariate logistic regression, with a total of 63 data sets after matching, and details of the matched patients are shown in Table 4. Based on the paired univariate logistics analysis of the matched population, we found that the potential risk factors between the survival group and the death

Table 1 Demographic and Clinical Characteristics of 398 Patients with *Acinetobacter baumannii* BSI

Characteristics	Total, n=398
Demographics	
Gender(male,%)	264(66.3)
Age(Years)	53.0±15.9
Hospital stay	20.0[11.0,35.0]
ICU stay	10.0[4.0,19.3]
Any comorbidity, n(%)	371(93.2)
Diabetes	75(18.8)
Hypertension	97(24.4)
Cardiovascular disease	96(24.1)
Cardiopulmonary Resuscitation	80(20.1)
Malignancy	42(10.6)
Renal failure	82(20.6)
Pulmonary infection	290(72.9)
Respiratory failure	195(49.0)
Invasive procedures	328(82.4)
Mechanical ventilation	237(59.5)
Surgery	207(52.0)
Condition prior to infection onset	
Hospital stay	11.0[6.0,19.0]
ICU stay	6.0[3.0,12.0]
Inpatient department	
ICU	316(79.4)
N-ICU	82(20.6)
Resistance	
Drug resistance (S-AB, %)	36(9.0)
Drug resistance (MDR-AB, %	145(36.4)
Drug resistance (XDR-AB, %)	207(52.0)
Drug resistance (PDR-AB, %)	10(2.5)
CRAB (%)	345(86.7)
Laboratory index	
White blood	9.1[5.2,13.9]
PCT	2.4[0.6,11.9]
CRP	103.2[34.9,118.7]
Lac	2.2[1.2,4.1]
Severity	
Septic shock	229(57.5)
GCS	9.0[4.0,14.0]
APACHE II	20.1±9.6
SOFA	10.0±5.4

Abbreviations: ICU, Intensive: Intensive Care Unit; N-ICU, non- Intensive: Intensive Care Unit; S-AB, Sensitive-Acinetobacter baumannii; MDR-AB, Multidrug resistance- Acinetobacter baumannii; XDR-AB, Extensive drug-resistance-Acinetobacter baumannii; PDR-AB, pandrug re-sistance-Acinetobacter baumannii; CRAB, carbapenem-resistant Acinetobacter baumannii; PCT, Procalcitonin; CRP, C-Reactive Protein; lac, Lactic Acid.

group were substantially reduced, and the death group was more likely to receive mechanical ventilation. Compared with the survival group, the dead patients' SOFA scores were higher, which lead to higher 28-day mortality. A higher APACHE score is no longer an independent risk factor for death. Furthermore, we incorporated the above factors into the paired multivariate logistics regression analysis. Table 5 depicts that mechanical ventilation in hospital, the high SOFA

Table 2 Univariate Logistic Regression Analysis for Risk Factors of 28-Day Mortality for Patients with *Acinetobacter baumannii* BSI

Characteristics	Survival (n=150)	Death(n=248)	OR(95% CI)	P
Demographics				
Gender(male,%)	99(66.0)	165(66.5)	0.976(0.636,1.499)	0.913
Age(Years)	51.5±15.0	53.9±16.4	1.009(0.997,1.022)	0.148
Hospital stay	31.0[19.75,47.5]	15.0[9.0,26.0]	0.965(0.953,0.976)	<0.001
ICU stay	9.0[0.0,24.25]	10.0[6.0,18.0]	0.995(0.982,1.008)	0.422
Any comorbidity, n(%)	140(93.3)	231(93.1)	0.991(0.636,1.502)	0.942
Diabetes	30(20.0)	45(18.1)	0.887(0.530,1.483)	0.647
Hypertension	38(25.3)	59(23.8)	0.920(0.575,1.472)	0.728
Cardiovascular disease	31(20.7)	65(26.2)	1.363(0.839,2.217)	0.211
Cardiopulmonary Resuscitation	2(1.3)	78(31.5)	33.953(8.201,140.573)	<0.001
Malignancy	15(10.0)	27(10.9)	1.100(0.565,2.141)	0.78
Renal failure	11(7.3)	71(28.6)	5.069(2.586,9.934)	<0.001
Pulmonary infection	81(54.0)	209(84.3)	4.565(2.856,7.297)	<0.001
Respiratory failure	32(21.3)	163(65.7)	7.071(4.417,11.320)	<0.001
Invasive procedures	104(69.3)	224(90.3)	4.128(2.392,7.124)	<0.001
Mechanical ventilation	89(59.3)	148(59.7)	8.538(5.366,13.586)	<0.001
Surgery	89(59.3)	118(47.6)	0.622(0.413,0.938)	0.023
Condition prior to infection onset				
Hospital stay	12.0[8.0,19.25]	10.0[6.0,17.8]	0.989(0.973,1.006)	0.209
ICU stay	4.5[0.0,12.0]	7.0[4.0,12.0]	1.021(0.996,1.047)	0.101
Inpatient department			0.171(0.102,0.288)	<0.001
ICU	89(59.3)	227(91.5)		
N-ICU	61(40.7)	21(8.5)		
Resistance				
Drug resistance (S-AB, %)	32(21.3)	4(1.6)	0.060(0.021,0.175)	<0.001
Drug resistance (MDR-AB, %	50(33.3)	95(38.3)	1.242(0.812,1.900)	0.318
Drug resistance (XDR-AB, %)	64(42.7)	143(57.7)	1.830(1.214,2.758)	0.004
Drug resistance (PDR-AB, %)	4(2.7)	6(2.4)	0.905(0.251,3.260)	0.879
CRAB (%)	105(70.0)	240(96.8)	12.857(5.857,28.222)	<0.001
Laboratory index				
White blood	8.9[6.0,13.5]	9.3[4.5,14.6]	0.996(0.970,1.023)	0.779
PCT	1.5[0.3,5.5]	3.5[0.8,14.9]	1.030(1.014,1.047)	<0.001
CRP	78.6[23.1,104.2]	104.2[44.9,155.0]	1.006(1.003,1.009)	<0.001
Lac	1.6[0.9,4.1]	2.8[1.5,6.1]	1.281(1.161,1.413)	<0.001
Severity				
Septic shock	41(27.3)	188(75.8)	1.778(1.159,2.728)	0.008
GCS	12.0[9.0,15.0]	6.0[3.0,12.0]	0.833(0.793,0.875)	<0.001
APACHE II	13.6±6.9	23.4±10.6	1.118(1.084,1.152)	<0.001
SOFA	6.1±3.9	12.3±4.8	1.413(1.314,1.519)	<0.001

Abbreviations: ICU, Intensive: Intensive Care Unit; N-ICU, non- Intensive: Intensive Care Unit; S-AB, *Sensitive-Acinetobacter baumannii*; MDR-AB, *Multidrug resistance- Acinetobacter baumannii*; XDR-AB, *Extensive drug-resistance-Acinetobacter baumannii*; PDR-AB, *pandrug re-sistance-Acinetobacter baumannii*; CRAB, *carbapenem-resistant Acinetobacter baumannii*; PCT, Procalcitonin; CRP, C-Reactive Protein; lac, Lactic Acid.

score at the time of infection, or septic shock are independent risk factors for 28-day mortality of *Acinetobacter baumannii* BSI.

Empirical Antibiotic Therapy for Patients with *Acinetobacter baumannii* BSI

Table 6 shows the association between inadequate empirical antibiotic therapy and mortality before and after propensity matching, with 175 (44%) patients receiving inappropriate empirical therapy before propensity score matching. Patients

Table 3 Multivariate Logistic Regression Analysis for Risk Factors of 28-Day Mortality for Patients with *Acinetobacter baumannii* BSI

Characteristics	OR(95% CI)	P value
Hospital stay	0.960(0.942,0.978)	<0.001
Cardiopulmonary Resuscitation	6.389(1.308,31.215)	0.022
Renal failure	3.427(1.146,10.251)	0.028
APACHE II	1.076(1.005,1.151)	0.034

Table 4 Univariate Logistic Regression Analysis for Risk Factors of 28-Day Mortality for Patients with *Acinetobacter baumannii* BSI After Propensity Score Matching

Characteristics	Survival, n=63	Death, n=63	OR (95% CI)	P
Demographics				
Gender(male,%)	99(66.0)	41(65.1)	1.250(0.585,2.670)	0.565
Age(Years)	52.87±14.00	53.16±15.77	1.001(0.978,1.025)	0.913
Hospital stay	35.0[22.0,44.0]	24.0[14.0,34.0]	0.985(0.969,1.002)	0.089
ICU stay	16.0[5.0,28.0]	14.0[6.0,27.0]	1.004(0.984,1.024)	0.7
Any comorbidity, n(%)	60(95.2)	58(92.1)	0.500(0.092,2.730)	0.423
Diabetes	11(17.5)	14(22.2)	1.429(0.544,3.753)	0.469
Hypertension	15(23.8)	14(22.2)	0.923(0.421,2.023)	0.842
Cardiovascular disease	9(14.3)	16(25.4)	1.875(0.795,4.422)	0.151
Cardiopulmonary Resuscitation	2(3.2)	7(11.1)	3.5(0.727,16.848)	0.118
Malignancy	4(6.3)	7(11.1)	1.750(0.512,5.978)	0.372
Renal failure	4(6.3)	9(14.3)	3.5(0.727,16.848)	0.118
Pulmonary infection	45(71.4)	48(76.2)	1.333(0.562,3.164)	0.514
Respiratory failure	22(34.9)	25(39.7)	1.250(0.585,2.670)	0.565
Invasive procedures	52(82.5)	50(79.4)	0.800(0.316,2.027)	0.638
Mechanical ventilation	21(33.3)	41(65.1)	5.000(1.914,13.061)	0.001
Surgery	41(65.1)	35(55.6)	0.647(0.303,1.381)	0.261
Condition prior to infection onset				
Hospital stay	12.0[8.0,20.0]	11.0[7.0,20.0]	0.989(0.973,1.006)	0.803
ICU stay	9.0[3.0,16.0]	8.0[4.0,13.0]	1.021(0.996,1.047)	0.587
Inpatient department			0.700(0.266,1.839)	0.469
ICU	49(77.8)	52(82.5)		
N-ICU	14(22.2)	11(17.5)		
Resistance				
Drug resistance (S-AB, %)	4(6.3)	2(3.2)	0.500(0.092,2.730)	0.423
Drug resistance (MDR-AB, %	50(33.3)	95(38.3)	1.242(0.812,1.900)	0.318
Drug resistance (XDR-AB, %)	39(61.9)	37(58.7)	0.875(0.427,1.793)	0.715
Drug resistance (PDR-AB, %)	4(2.7)	6(2.4)	0.905(0.251,3.260)	0.879
CRAB (%)	58(92.1)	59(93.7)	1.250(0.336,4.655)	0.739
Laboratory index				
White blood	10.1[6.64,13.9]	9.7[6.7,13.2]	0.958(0.894,1.026)	0.218
PCT	0.77[0.23,3.01]	1.79[0.54,6.29]	1.022(0.986,1.059)	0.237
CRP	99.2[38.9,104.21]	104.21[44.47,109.14]	1.003(0.997,1.008)	0.354
Lac	1.5[1.0,2.3]	1.9[1.2,3.2]	1.122(0.919,1.368)	0.258
Severity				
Septic shock	38(60.3)	48(76.2)	2.429(1.007,5.856)	0.048
GCS	12.0[7.0,14.0]	10.0[5.0,15.0]	0.948(0.870,1.034)	0.228
APACHE II	16.93±6.20	18.67±6.91	1.051(0.988,1.118)	0.112
SOFA	6.63±3.79	8.27±3.99	1.266(1.084,1.479)	0.003

Abbreviations: ICU, Intensive: Intensive Care Unit; N-ICU, non- Intensive: Intensive Care Unit; S-AB, *Sensitive-Acinetobacter baumannii*; MDR-AB, *Multidrug resistance- Acinetobacter baumannii*; XDR-AB, *Extensive drug-resistance-Acinetobacter baumannii*; PDR-AB, *pandrug resistance-Acinetobacter baumannii*; CRAB, *carbapenem-resistant Acinetobacter baumannii*; PCT, Procalcitonin; CRP, C-Reactive Protein; lac, Lactic Acid.

Table 5 Multivariate Logistic Regression Analysis for Risk Factors of 28-Day Mortality for Patients with *Acinetobacter baumannii* BSI After Propensity Scoring Match

Characteristics	OR(95% CI)	P value
Septic shock	2.098(0.767,5.744)	0.015
Mechanical ventilation	4.027(1.444,11.229)	0.008
SOFA	1.197(1.015,1.412)	0.032

Table 6 Comparison of Patients with *Acinetobacter baumannii* BSI Treated with Appropriate Empirical Antibiotic Therapy and Inappropriate Empirical Antibiotic Therapy Before and After Propensity Scoring Match

Empirical Antibiotic Therapy	Before PSM				After PSM			
	Survival, n=150	Death, n=248	OR(95% CI)	P-value	Survival, n=63	Death, n=63	OR (95% CI)	P-value
Appropriate empirical antibiotic therapy	90(60.0%)	133(53.6%)	1.297 (0.860,1.956)	0.215	38(60.3%)	24(38.1%)	2.556 (1.183,5.523)	0.017
Inappropriate empirical antibiotic therapy	60(40.0%)	115(46.4%)			25(39.7%)	39(61.9%)		

in the death group were more likely to receive inappropriate empirical treatment than those in the survival group. However, there was no significant correlation between the two groups. After propensity score matching, patients in the death group were still more likely to receive inappropriate empirical treatment than those in the survival group. Thankfully, we found that receiving inappropriate empirical treatment will significantly increase the risk of 28-day death of *Acinetobacter baumannii* BSI.

Discussion

The incidence of BSI with high morbidity and mortality is increasing worldwide.[17] Although effective antibiotic use is constantly updated, BSI remains one of the seven leading causes of death in middle-and high-income countries.[18] *Acinetobacter baumannii* was on the Priority List of Antibiotic-Resistant Bacteria in the Global essential Study Category by the World Health Organization (WHO).[19] A multicenter cohort study conducted in 24 countries found that It was the most common pathogen that caused hospital-acquired BSI.[5] An analysis of an observational study conducted in 12 large tertiary hospitals in 7 Italian regions reported a 30-day mortality of 73.6% for BSI caused by *Acinetobacter baumannii*.[20] A systematic review of matched cohort and case-control studies[21] concluded that the infection with *Acinetobacter baumannii* was associated with increased mortality. The BSI caused by *Acinetobacter baumannii* has been paid more and more attention in the clinic because of its high fatality rate.[22] Therefore, studying the prognostic factors of *Acinetobacter baumannii* BSI is necessary.

The increasing use of carbapenem-resistant drugs and the tenacious adaptability of *Acinetobacter baumannii* make its Drug-resistant strains increasingly tricky.[23,24] For a long time, the question of whether drug resistance is a high risk factor for death of *Acinetobacter baumannii* BSI has remained ambiguous, and This study found that The resistance of *Acinetobacter baumannii* had nothing to do with a worse clinical prognosis before and after Propensity score matching, this was in line with previous reports in the relevant literature;[9,25] however, some studies still supported that drug resistance could increase the mortality of *Acinetobacter baumannii* BSI patients.[26,27] Interestingly, Santoro et al[28] discovered that BSI caused by MDR bacteria did not significantly increase mortality after precise stratification of bacterial resistance patterns. On the other hand, BSI caused by *XDR gram-negative bacteria* was a powerful predictor of death. In our opinion, the presence of drug resistance in *Acinetobacter baumannii* will only give rise to more and more inappropriate empirical antibiotic therapy, and ultimately, it is the inappropriate empirical antibiotic therapy that is

a direct predictor of mortality. A matched control study based on comorbidity, age, and septic shock may towards a better understanding of the role of antibiotic resistance in the clinical outcome of patients with *Acinetobacter baumannii*.[29]

In this study, compared with the survival group, people in the death group received more Inappropriate empirical antibiotic therapy before the propensity scoring match, then, the results in the matching queue based on the propensity score, showed that inappropriate empirical antibiotic therapy remained frequently in the death group and significantly affected the prognosis of patients with *Acinetobacter baumannii* BSI. Some researchs demonstrated that controlling the patient's baseline status and risk factors of death, especially the patient's comorbidities and severity of the disease, which were key confounding factors in the relationship between appropriate empirical antibiotic treatment and patient mortality, can more effectively derive the efficacy of empiric antibiotics.[30,31] Subsequently based on that evidence, we found out, As soon as possible to carry out the appropriate empiric therapy seemed to be a more attractive strategy compared with the positive experience therapy of broad-spectrum antibiotics which are widely used.[22,32] Even every day matters.[33] Of course, not only the empirical antibiotic therapy but also the definitive therapy was related to the prognosis of patients with *Acinetobacter baumannii* BSI. Some studies showed that colistin-containing therapies were associated with survival rates. Accepted loading doses of colistin in patients with CRAB improved their 30-day survival.[34,35] Cancer patients with CRAB infection, who received a long course (≥14 days) of colistin had a lower 30-day mortality but the same nephrotoxicity compared with the short course (<14 days).[36] For further, the available studies have not reached a consistent conclusion on whether colistin-based combination therapies can reduce the mortality of *Acinetobacter baumannii* BSI patients.[37–40] Therefore, more clinical data are needed for observational analysis in order to improve the prognosis of *Acinetobacter baumannii* BSI. This is also the direction that our study will focus on in the future.

Acinetobacter baumannii BSI prefers patients with severe diseases. In this study, APACHE, SOFA, and septic shock were used to evaluate the patient's condition, which is unique and comprehensive. The prognostic analysis only showed that a higher APACHE score was related to a worse prognosis before propensity matching; then, SOFA score and septic shock demonstrated good predictive power for 28-day mortality of *Acinetobacter baumannii* BSI in the matched population. We confirmed that a higher SOFA score and septic shock were reliable predictors of mortality in conditions that control for comorbidities and disease severity,[41] which significantly affect prognosis, and the APACHE score was no longer an independent predictor of death; our study may indicate. Compared with the APACHE score on admission, the factor that can really judge the prognosis of *Acinetobacter baumannii* BSI patients lies in the severity of bacteremia, or perhaps the APACHE score may be a vital factor in judging the prognosis of some other diseases. However, for patients with *Acinetobacter baumannii* BSI, there is still a lack of ability to predict prognosis. Worthy of further research. And the matched population was more likely to receive inappropriate empirical therapy, which coincided with the research of Su-Jung Chen et al.[42] The difference was that we added the indicator of septic shock to assess the severity of disease, because neither APACHE nor SOFA score included information such as septic shock; however, septic shock often means severe infection, which usually occurs in critically ill patients, They are more likely to die after a lethal hit. We agreed that it was a good indicator for evaluating the severity of the disease and predicting the mortality of bacteremia. Our finding was in accordance with recent literature reports.[43,44]

In our study, more than half of the patients came from ICU, meaning more invasive procedures. The pulmonary infection has become the primary comorbidity in this cohort. Ultimately, mechanical ventilation during hospitalization was considered to increase the mortality of *Acinetobacter baumannii* BSI Significantly, it was suggested that pulmonary colonization might be the primary source of *Acinetobacter baumannii* BSI; further study is needed. In addition, most of the patients who received mechanical ventilation were in serious condition, which may support that the severity of the disease can significantly affect the 28-day prognosis of *Acinetobacter baumannii* BSI.

It is rare for our research to use propensity score matching in analyzing the factors related to the 28-day prognosis of the *Acinetobacter baumannii* BSI. Compared with simple logistics regression analysis, propensity score matching adjusted for more confounding factors and equalized differences in baseline to make the results more convincing. In addition, we conducted multivariate analyses to ensure that statistically significant confounders of clinical credibility were retained in our final multivariate model to reflect the actual relationship between research indicators and mortality. Thus, that is, patients with *Acinetobacter baumannii* BSI who have higher SOFA score at the time of infection, with septic shock, or mechanical ventilation, and Inappropriate empirical antibiotic therapy were more likely to be fatally hit within 28 days and had a poor prognosis.

The limits of research are as follows. Firstly, there is an inevitable selection bias in the design of the retrospective study and we could not exclude the effect of unmeasured variables or unknown confounders, for example, we only collected information on mechanical ventilation and surgery for invasive procedures but failed to include the more common invasive procedures such as the central venous catheter; secondly, our research may lack the ability to distinguish the death caused by *Acinetobacter baumannii* from that caused by other factors, which is also a matter of concern in the future. In the end, single-center research may lack some universality, multicenter, prospective research is needed to identify further prognostic factors affecting patients with *Acinetobacter baumannii* BSI.

Conclusion

In summary, we showed that patients with *Acinetobacter baumannii* BSI had a high 28-day mortality rate. For such patients, clinicians should pay close attention to the patient's conditions, especially those with high SOFA scores at the time of infection, with septic shock during hospitalization, or mechanical ventilators, by reason of such patients tend to predict poor clinical outcomes; moreover, providing patients with appropriate empirical antibiotic therapy can best improve survival.

Data Sharing Statement

Data are available upon reasonable request to the corresponding author.

Author Contributions

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

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