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Major article

Comparison of pneumonia and nonpneumonia-related *Acinetobacter baumannii* complex bacteremia: A single-center retrospective study

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Key Words:
Pneumonia-related ABC bacteremia
Immunosuppression
Risk factors
30-day mortality

Background: *Acinetobacter baumannii* complex (ABC) is a group of increasingly prevalent opportunistic pathogens that cause a variety of life-threatening nosocomial infections, especially in the intensive care unit (ICU). This study assessed the differences between pneumonia- and non-pneumonia-related ABC bacteremia and possible independent risk factors for 30-day mortality.

Methods: The clinical data of ICU patients diagnosed with ABC bacteremia at a tertiary care hospital from January 2009 to December 2020 were collected, and sorted into groups of ABC bacteremia with and without pneumonia.

Results: Significant changes in the incidence of ABC bacteremia and antibiotic resistance were observed over the 12-year study. Compared with nonpneumonia-related ABC bacteremia, pneumonia-related ABC bacteremia was associated with a higher rate of hypertension, less prior tigecycline use, more carbapenem-resistant (CR) strains, and a higher 30-day mortality rate. In multivariate analysis, immunosuppression, higher APACHE II score, and SOFA score were independent risk factors for 30-day mortality. Moreover, the risk of death was 1.919 times higher in the pneumonia-related group.

Conclusions: Although pneumonia-related ABC bacteremia had worse outcomes, it was not an independent risk factor for death statistically. Immunosuppression and disease severity levels increased the risks of death in ICU patients with ABC bacteremia.

BACKGROUND

Acinetobacter baumannii complex (ABC), a group of aerobic nonfermenting Gram-negative coccobacilli, has become one of the most prominent opportunistic nosocomial pathogens. It causes severe nosocomial infections worldwide, especially in intensive care units (ICUs).[1] ABC is frequently distributed in ICU environments and can colonize human mucosal surfaces and medical devices.[2] Infections caused by ABC at multiple anatomical sites include ventilator-associated pneumonia (VAP), bloodstream infection (BSI), abdominal infection, skin and soft tissue infections, and catheter-associated urinary tract infections.[1]

Compared with ABC infections at other sites, clinicians focus on ABC bacteremia due to its high mortality rate,[3] longer hospital stays, and greater costs.[4] The reported mortality rate in patients with ABC bacteremia is 30%-65%.[5,6] Furthermore, due to increased antibiotic exposure, the incidences of multidrug-resistant (MDR) and carbapenem-resistant (CR) ABC are increasing alarmingly. Clinical treatment becomes very difficult once bacteremia is caused by MDR and CR ABC, which is also associated with a higher mortality.[3,7] Many studies have shown that the epidemiology of ABC bacteremia and the antimicrobial susceptibility profiles of ABC isolates vary greatly depending on the region, year, and even hospital ward. Therefore, it is necessary to investigate changes in the prevalence, microbiological characteristics, treatments, and prognosis in a local context. Reported risk factors for mortality in patients with ABC bacteremia include old age, malignancy, acute kidney injury, septic shock, ICU stay, previous antibiotic use, and illness severity, as defined by the Pitt bacteremia, Acute Physiology and Chronic Health Evaluation II (APACHE II) or Sequential Organ Failure Assessment (SOFA) score, a Charlson

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comorbidity index>3, lower albumin levels, a respiratory tract bacteremia origin, carbapenem resistance, and inappropriate initial antimicrobial therapy.[3,8-12] Zhou et al[10] and Liu et al[13] have suggested that a respiratory tract bacteremia origin may be an independent risk factor for mortality, although other studies[8,14] have refuted this. Whether pneumonia-related ABC bacteremia is an independent risk factor still needs to be assessed by clinical studies. A recent retrospective cohort study of Chinese ICUs found that the incidence of ABC bacteremia and prevalence of antibiotic resistance increased markedly during the past decade, along with increasing pneumonia-related infections and worrisome mortality.[15]

Therefore, we performed this single-center retrospective study to explore differences in clinical profile and prognosis between patients with pneumonia- and nonpneumonia-related ABC bacteremia, and identified possible independent risk factors for 30-day mortality.

PATIENTS AND METHODS

Study design

A retrospective study was conducted in the 29-bed ICU of the First Affiliated Hospital, College of Medicine, Zhejiang University January 2009 to December 2020. The study was reviewed and approved by the Ethics Committees of The First Affiliated Hospital, College of Medicine, Zhejiang University (IIT20210605A).

Patient selection, variables, and definitions

Using laboratory records, ICU patients (aged≥ 18 years) with symptoms and signs of infection and at least 1 ABC-positive blood culture were enrolled. For patients with multiple episodes of ABC bacteremia, only the first episode was included. Exclusion criteria were aged <18 years, incomplete medical history, ABC bacteremia only isolated from a central catheter line tip culture without a peripheral positive blood culture, no sepsis, and a diagnosis of ABC bacteremia before ICU admission. Patients with coinfection by other pathogens at other sites were not excluded. A total of 188 patients were eligible for inclusion in the study and were sorted into groups of ABC bacteremia with and without pneumonia (Fig 1).

The paper and electronic medical records were reviewed and the following data were collected: general patient data (ie, age, gender, and underlying diseases), primary admission diagnosis, invasive procedures before bacteremia (ie, central venous catheter (CVC) placement, temporary dialysis tube placement, tracheal intubation, etc.), antibiotic and steroid exposure, Charlson comorbidity index, the Pitt bacteremia, APACHE II, and SOFA scores, the blood culture and antimicrobial susceptibility results, laboratory test results, clinical manifestations of bacteremia, treatment, microbiological eradication, total hospital, and ICU stay durations, mechanical ventilation (MV) time, and 7- and 30-day mortality. The primary outcome was 30-day mortality and the secondary outcomes were total hospital and ICU stay durations, MV time, microbiological eradication rate, and 7-day mortality.

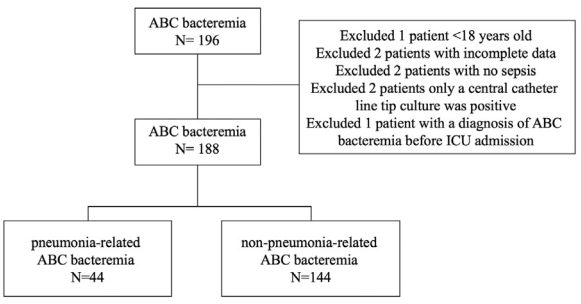

Fig 1. Study flow chart. ABC, Acinetobacter baumannii complex.

Pneumonia-related bacteremia was defined using three items based on The Centers for Disease Control and Prevention (CDC) guidelines (https://www.cdc.gov/nhsn/pdfs/pscmanual/4psc_clabscurrent.pdf). The drug susceptibility results were consistent for positive blood and sputum cultures; a sputum culture was collected within the infection window (3 days before and after the first positive blood test), and the clinical diagnostic criteria for pneumonia were met. The severity of illness was rated using the Pitt bacteremia, APACHE II, or SOFA score at the time of bacteremia. Previous corticosteroid use was defined as the use of corticosteroids at a mean minimum dose of 0.3 mg/kg/d of prednisone equivalent for at least 72 hours, within 30 days before the onset of bacteremia. Chronic renal failure was defined as an estimated glomerular filtration rate of <60 mL/min/1.73 m2. Liver cirrhosis was diagnosed based on laboratory and radiological evidence. Immunosuppression was defined as a history of any of the following: corticosteroid therapy for 15 days (at least 10 mg/d of prednisone or an equivalent drug); seropositivity for human immunodeficiency virus; solid organ or bone marrow transplantation; radiotherapy or chemotherapy for an underlying malignancy during the 6 months before hospital admission; and acquired immune deficiency disorder (ie, hypogammaglobulinemia or combined variable immunodeficiency).[16] Appropriate antimicrobial therapy was defined as the administration of at least 1 antimicrobial agent, to which a pathogen was sensitive in vitro within 48 hours of bacteremia, via an approved route and at a dosage appropriate for end organ function.[13] Septic shock was defined as sepsis-induced hypotension persisting despite adequate fluid resuscitation according to the Sepsis 3.0 guidelines jointly issued by the Society of Critical Care Medicine (SCCM) and the European Society of Intensive Care Medicine (ESCIM) in 2016.[17] Microbiological eradication was determined if documented or presumed, the baseline isolate was absent in repeat cultures obtained from the original infection site, or a clinical cure made repeat culture unnecessary.[18]

Identification and antimicrobial susceptibility testing

Blood specimens drawn at the bedside under sterile conditions were processed in an automated blood culture machine. The blood isolates were identified by the Vitek system (bioMe´rieux) or a MALDI Biotyper (Bruker). Based on the Vitek system, it is unable to identify species. Susceptibility of the ABC isolates was assessed by the Vitek system. The susceptibility results were interpreted according to the Clinical Laboratory Standards Institute criteria. Intermediate resistance was regarded as resistance in our study.

Statistical methods

The mean ± standard deviation was calculated for continuous variables with a normal distribution, and median (interquartile range) was calculated for those with a non-normal distribution. Student's t test and the Mann-Whitney test were used to analyzing continuous variables, as appropriate. Categorical variables were evaluated by the $\chi 2$ test or Fisher's exact test. All significance tests were 2-sided and *P*-values <.05 were considered statistically significant. All variables with a *P*-value <.05 in the univariate analyses were included in the multivariate analysis. Linear regression was used to test the multicollinearity between statistically significant variables (*P*-value <.05) in univariate analyses and tolerance and variance inflation factor (VIF) were calculated. We used SPSS software (ver. 26.0; IBM Corp) for the statistical analysis and Python 3.8 for visualizations.

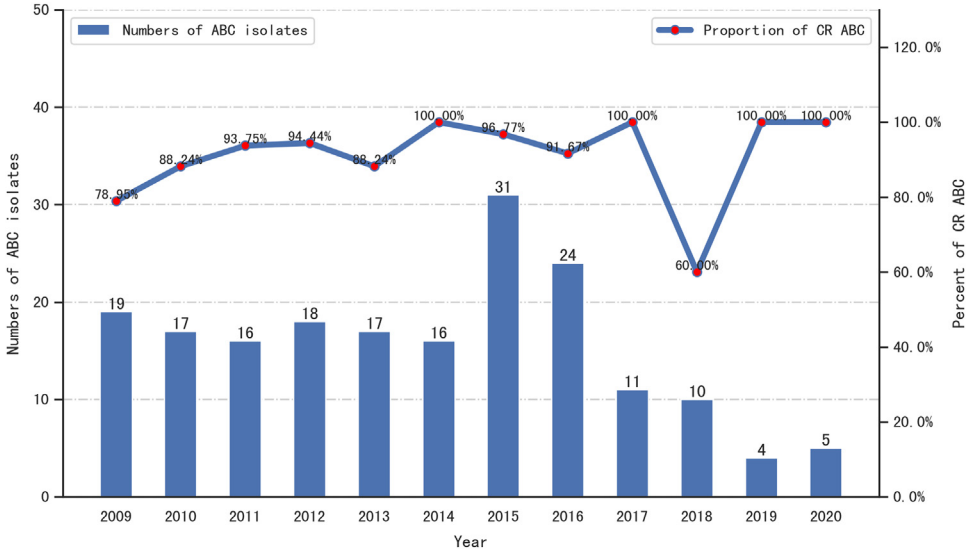

Fig 2. The annual frequency of ABC bacteremia and the annual trend of CR ABC bacteremia from January 2009 to December 2020. Data are presented as integer or percentage. Blue bars, the frequency of ABC bacteremia during 2009-2020; Data point-fold line chart, the proportion of CR ABC by year.

RESULTS

Patient demographics and the incidence of ABC bacteremia by year

The study enrolled 188 patients with ABC bacteremia during the 12-year period from 2009 to 2020. Their average age was 60.9 ± 17.1 years old and 136 (72.3%) were male. The median total ICU stay was 15 days, and the overall 30-day mortality was 61.7%. For the period 2009-2014, there was no significant change in the frequency of ABC bacteremia by year, while the proportion of CR ABC increased from 78.95% to 100%. The frequency of ABC bacteremia peaked in 2015 and then decreased until 2020. For 2017-2020, the rate of carbapenem resistance was 100%, except in 2018, when it was 60% (Fig 2).

The different clinical characteristics of patients with pneumonia-related and nonpneumonia-related ABC bacteremia

The 188 patients were divided into two groups with pneumonia-(23.4%, 44/188) and nonpneumonia-(76.6%, 144/188) related ABC bacteremia. Table 1 shows their demographics and clinical characteristics. The pneumonia-related group was slightly older (65.3±15.1 vs 59.5±17.5, *P*=.051) and tended to have the underlying disease of hypertension (*P*=.003). The 2 groups did not differ significantly in gender, prior use of corticosteroids, length of ICU prior to culture, invasive procedures, and the severity of illness based on the Charlson comorbidity index. Antibiotic exposure prior to their admission to the ICU was no statistical difference, except for tigecycline (*P*=.030). On the day of bacteremia, there were no significant differences in serum albumin, immunosuppression, appropriate antimicrobial therapy, infection severity based on the Pitt bacteremia score, APACHE II score, SOFA score, septic shock, or maximum lactate between the 2 groups. The proportion of carbapenem-resistant strains in the pneumonia-related group and the nonpneumonia-related group was 100% and 88.2%, respectively (*P*=.014).

The outcomes of 188 patients with ABC bacteremia are shown in Table 2. Patients with pneumonia-related ABC bacteremia were similar to patients with nonpneumonia-related ABC bacteremia with respect to the length of ICU stay, duration of MV, microbiological eradication, and 7-day mortality. The 30-day mortality rate was significantly higher in the pneumonia-related group (75.0% vs 57.6%, *P*=.038), which led to a shorter hospital stay instead.

Risk factors for 30-day mortality in patients with ABC bacteremia

Table 3 shows risk factors for 30-day mortality in patients with ABC bacteremia. Taking death within 30 days after ABC bacteremia diagnosis as the main endpoint, 116 cases died and 72 survived. The 30-day mortality rate of patients with ABC bacteremia was 61.7%.

In univariate analyses, poor outcomes were associated with hematological malignancy, previous corticosteroid use, prior exposure to quinolone and antifungal agents, CR strains, monomicrobial bacteremia, respiratory tract as the origin of bacteremia, lower albumin and higher lactate levels at the time of bacteremia, immunosuppression, septic shock, and severity of illness based on the Pitt bacteremia, APACHE II, and SOFA scores at the time of bacteremia. The tolerance and variance inflation factor (VIF) was calculated to prove that there is no multicollinearity in above variables.

On multivariate logistic regression analysis, immunosuppression (OR 3.883, 95%CI 1.665-9.058, *P*=.002), APACHE II score (OR 1.084, 95%CI 1.025-1.148, *P*=.005) and SOFA score (OR 1.244, 95%CI 1.110-1.395, *P*<.001) at the time of bacteremia remained independent risk factors for 30-day mortality. The risk of death was 1.919 times higher in the pneumonia-related group, although there was no statistical difference (*P*=.171).

DISCUSSION

Acinetobacter baumannii complex is a group of nosocomial pathogens that has emerged as a devastating public health threat in healthcare settings, and particularly in ICUs, where it is widely distributed and can colonize human mucosal surfaces and invade the bloodstream in critically ill patients with impaired immune function. There are few treatment options and infections caused by MDR and CR ABC can lead to higher mortality.[19] Several studies have suggested that respiratory tract colonization or infection is a risk factor for ABC bacteremia,[19] but few have compared the clinical characteristics of pneumonia- and nonpneumonia-related ABC bacteremia.[13] This 12-year retrospective single-center study examined long-term changes in incidence and antibiotic resistance among patients with ABC bacteremia in an ICU in eastern China, and compared the differences between pneumonia- and nonpneumonia-related ABC bacteremia and identify possible independent risk factors for 30-day mortality.

Table 1
Demographic and clinical characteristics of 188 patients with ABC bacteremia with and without pneumonia

Patient characteristics	Pneumonia-related bacteremia (n=44)	Nonpneumonia-related bacteremia (n=144)	*P*
Age	65.3 ± 15.1	59.5 ± 17.5	.051
Male sex	11 (25.0)	41 (28.5)	.652
Underlying diseases			
Hypertension	25 (56.8)	46 (31.9)	**.003**
Diabetes mellitus	9 (20.5)	23 (16.0)	.489
Coronary artery disease	9 (20.5)	22 (15.3)	.418
Solid-organ malignancy	11 (25.0)	24 (16.7)	.214
Hematological malignancy	2 (4.5)	11 (7.6)	.736
Post-transplantation	2 (4.5)	5 (3.5)	.667
Chronic Renal Failure	8 (18.2)	23 (16.0)	.730
Liver cirrhosis	4 (9.1)	10 (6.9)	.734
Chronic obstructive pulmonary disorder	12 (27.3)	23 (16.0)	.092
Cerebrovascular disease	7 (15.9)	10 (6.9)	.079
Connective tissue disorder	5 (11.4)	13 (9.0)	.770
Charlson Comorbidity Index	2.6 ± 2.3	2.3 ± 2.3	.348
Corticosteroid use	13 (29.5)	30 (20.8)	.229
Length of ICU prior to culture	7.0 (2.3, 11.8)	7.0 (3.0,14.0)	.569
Invasive devices and procedures			
Recent major surgery (with 1 mo)	12 (27.3)	58 (40.3)	.118
Mechanical ventilation			
Endotracheal tube	42 (95.5)	121 (84.0)	.051
Tracheostomy	12 (27.3)	40 (27.8)	.948
Fiberoptic bronchoscopy	12 (27.3)	21 (14.6)	.053
Central venous catheter	35 (79.5)	109 (75.7)	.597
Peripherally inserted central catheter	4 (9.1)	13 (9.0)	.990
Urinary catheter	39 (88.6)	130 (90.3)	.777
Continuous renal replacement therapy	20 (45.5)	51 (35.4)	.229
Percutaneous drainage	16 (36.4)	58 (40.3)	.642
Previous antibiotic used (with 1 mo)			
Antipseudomonal penicillins + beta lactamase inhibitors	29 (65.9)	85 (59.0)	.414
Antipseudomonal cephalosporins	7 (15.9)	36 (25.0)	.209
Carbapenems	32 (72.7)	95 (66.0)	.402
Quinolone	17 (38.6)	40 (27.8)	.170
Aminoglycosides	2 (4.5)	9 (6.3)	.956
Tigecycline	1 (2.3)	20 (13.9)	**.030**
Antifungal agents	22 (50.0)	57 (39.6)	.221
On bacteraemia day			
Serum albumin	31.1 ± 5.2	3.5 ± 2.5	.444
Immunosupression	20 (45.5)	54 (37.5)	.345
Proportion of carbapenem-resistant strains	44 (100.0)	127 (88.2)	**.014**
Appropriate antimicrobial therapy	7 (15.9)	34 (23.6)	.270
Severity of infection			
Pitt bacteremia score	5.9 ± 2.9	5.2 ± 3.2	.187
APACHE II score	26.9 ± 9.4	25.4 ± 11.0	.404
SOFA score	11.7 ± 5.5	10.5 ± 5.5	.188
Septic shock	27 (61.4)	66 (45.8)	.071
Maximum lactate (in 24 h)	3.5 ± 2.5	4.2 ± 3.8	.155

Data are presented as n (%) or mean ± SD or median [IQR].
APACHE, Acute Physiology and Chronic Health Evaluation; *IQR*, interquartile range; *SD*, standard deviation; *SOFA*, Sequential Organ Failure Assessment.
The bold values represent significant p<0.05.

A nationwide prospective cohort study conducted from 2007 to 2016 in 16 teaching hospitals across China suggested that A. *baumannii* was one of the top four pathogens responsible for bacteremia, accounting for approximately 7.03% of bloodstream bacterial isolates.[20] Data from the China Antimicrobial Surveillance Network (CHINET) revealed significant increases in the rates of resistance to carbapenem antibiotics, which ranged from 31% in 2005 to 79.2% in 2018.[21] A recent study revealed that the frequency of ABC bacteremia increased significantly in the ICUs in eastern China during 2009-2018, as did the resistance rate to carbapenem.[15] In this study, the resistance rate to imipenem was 95.7% in year 2017-2018, which is higher than in the CHINET data. We analyzed the clinical data of

Table 2
Outcomes of 188 patients with ABC bacteremia with and without pneumonia

	Pneumonia-related bacteremia (n=44)	Nonpneumonia-related bacteremia (n=144)	*P*
Duration of ICU	13.0 (6,19.8)	17.0 (8.0,31.0)	.079
Duration of hospital	16.5 (8.0,29.5)	27 (12.5,42.0)	**.013**
Duration of MV	13 (6,17.8)	12.5 (4.0,29.0)	.700
7-d mortality	24 (54.5)	60 (41.7)	.133
30-d mortality	33 (75.0)	83 (57.6)	**.038**
Microbiological eradication	12 (27.3)	61 (42.4)	.072

Data are presented as n (%) or median [IQR].
ICU, intestine care unit; *IQR*, interquartile range; *MV*, mechanical ventilation.
The bold values represent significant p<0.05.

Table 3
Risk factors for 30-day mortality in patients with ABC bacteremia

				Multivariate analysis	
Patient characteristics	Mortality (n=116)	Survival (n=72)	Univariate analysis, *P*	OR (95% CI)	*P*
Age	62.5 ± 15.5	58.2 ± 19.1	.109 (-9.619,.980)		
Male sex	81 (69.8)	55 (76.4)	.328 (.365,1.402)		
Underlying diseases					
Hypertension	46 (39.7)	25 (34.7)	.498 (.670,2.277)		
Diabetes mellitus	21 (18.1)	11 (15.3)	.616 (.552,2.721)		
Coronary artery disease	21 (18.1)	10 (13.9)	.449 (.605,3.106)		
Solid-organ malignancy	21 (18.1)	14 (19.4)	.818 (.432,1.941)		
Hematological malignancy	13 (11.2)	0 (0)	**.002 (.520,.666)**		.096
Post-transplantation	6 (5.2)	1 (1.4)	.254 (.457,32.848)		
Chronic Renal Failure	23 (19.8)	8 (11.1)	.117 (.833,4.700)		
Liver cirrhosis	12 (10.3)	2 (2.8)	.055 (.877,18.600)		
Chronic obstructive pulmonary disorder	21 (18.1)	14 (19.4)	.818 (.432,1.941)		
Cerebrovascular disease	11 (9.5)	6 (8.3)	.789 (.407,3.264)		
Connective tissue disorder	13 (11.2)	5 (6.9)	.334 (.576,4.962)		
Charlson Comorbidity Index	2.5 ± 2.4	2.0 ± 2.2	.146 (-1.179,.176)		
Corticosteroid use	39 (33.6)	4 (5.6)	**<.001 (2.926,25.341)**		.095
Length of ICU prior to culture	7.0 (2.0,13.0)	7.5 (4.3,14.0)	.310 (-4.682,17.186)		
Invasive devices and procedures					
Recent major surgery (within 1month)	37 (31.9)	33 (45.8)	.055 (.302,1.015)		
Mechanical ventilation					
Endotracheal tube	104 (89.7)	59 (81.9)	.130 (.819,4.455)		
Tracheostomy	30 (25.9)	22 (30.6)	.484 (.413,1.521)		
Fiberoptic bronchoscopy	19 (16.4)	14 (19.4)	.591 (.378,1.741)		
Central venous catheter	94 (81.0)	50 (69.4)	.068 (.949,3.723)		
Peripherally inserted central catheter	10 (8.6)	7 (9.7)	.798 (.318,2.415)		
Urinary catheter	104 (89.7)	65 (90.3)	.890 (.349,2.493)		
Continuous renal replacement therapy	47 (40.5)	24 (33.3)	.323 (.737,2.518)		
Percutaneous drainage	43 (37.1)	31 (43.1)	.414 (.428,1.419)		
Possible source of bacteremia					
Lung	71 (61.2)	38 (52.8)	.255 (.779,2.558)		
Intra-abdomen	16 (13.8)	14 (19.4)	.304 (.302,1.456)		
Catheter-related	14 (12.1)	10 (13.9)	.716 (.356,2.033)		
Urinary tract	5 (4.3)	5 (6.9)	.654 (.168,2.163)		
Unknown	11 (9.5)	5 (6.9)	.544 (.467,4.220)		
Previous antibiotic used (within 1 mo)					
Anti-pseudomonal penicillins + beta lactamase inhibitors	73 (62.9)	41 (56.9)	.414 (.705,2.338)		
Antipseudomonal cephalosporins	30 (25.9)	13 (18.1)	.215 (.763,3.286)		
Carbapenems	84 (72.4)	43 (59.7)	.071 (.950,3.299)		
Quinolone	43 (37.1)	14 (19.4)	**.011 (1.218,4.888)**		.141
Aminoglycosides	5 (4.3)	6 (8.3)	.339 (0.146,1.687)		
Tigecycline	12 (10.3)	9 (12.5)	.648 (0.322,2.025)		
Anti-fungal agents	60 (51.7)	19 (26.4)	**.001 (1.579,5.658)**		.176
On bacteraemia day					
Serum albumin	29.7 ± 5.1	31.9 ± 4.9	**.005 (0.654,3.619)**		.164
Immunosupression	60 (51.7)	14 (19.4)	**<.001 (2.231,8.831)**	**3.883 (1.665,9.058)**	**.002**
Proportion of carbapenem-resistant strains	110 (94.8)	61 (84.7)	**.019 (1.165,9.379)**		.790
Pneumonia-related	33 (28.4)	11 (15.3)	**.038 (1.033,4.706)**		**.171**
Appropriate antimicrobial therapy	22 (18.9)	19 (26.4)	.231 (.324,1.315)		
Severity of infection					
Pitt bacteremia score	6.4 ± 2.9	3.6 ± 2.7	**<.001 (-3.596, -1.919)**		.902
APACHE II score	30.0 ± 9.9	18.8 ± 7.7	**<.001 (-13.832, -8.737)**	**1.084 (1.025,1.148)**	**.005**
SOFA score	13.2 ± 5.1	6.9 ± 3.6	**<.001 (-4.010, -1.623)**	**1.244 (1.110,1.395)**	**<.001**
Septic shock	78 (67.2)	15 (20.8)	**<.001 (3.919,15.525)**		.145
Maximum lactate (in 24 h)	5.1 ± 4.1	2.3 ± 1.2	**<.001 (-3.539, -1.939)**		.157

Data are presented as n (%) or mean ± SD or median [IQR].
APACHE, Acute Physiology and Chronic Health Evaluation; *IQR*, interquartile range; *SD*, standard deviation; *SOFA*, Sequential Organ Failure Assessment.
The bold values represent significant p<0.05.

patients with ABC bacteremia during the past 12 years. Carbapenem-sensitive strains accounted for only 9.0% of the total number of cases and the proportion of CR strains was 100% in 2017, 2019, and 2020. There was a sudden drop in 2018 and the possible cause was that we performed strict rectification after a hospital sense event. However, the frequency of ABC bacteremia decreased recently (2015-2020), contrary to previous research. In our hospital in 2020, ABC had fallen out of the top 10 pathogens for bacteremia, suggesting that bacterial epidemiological studies in local hospitals are even more important.

ABC is commonly isolated from intubated patients in ICUs; in this study, lower respiratory tract infections were the most common source of ABC bacteremia acquired in the ICU. The reported mortality rate was higher in cases in which the respiratory tract was the source of bacteremia.[13] Although researchers have reported risk factors for MDR and CR acquisition in ABC bacteremia,[10,11,22] only Teng et al compared pneumonia and non-pneumonia patients with ABC bacteremia.[23] As shown in Table 1, our pneumonia-related group had a significantly higher rate of hypertension and significantly more CR strains, while the non-pneumonia-related group had a significantly

higher rate of previous tigecycline use. Compared with the non-pneumonia-related group, patients with pneumonia-related ABC bacteremia had a higher 30-day mortality rate, which decreased the total hospital stay because of the high mortality. This finding differed slightly from that of Teng et al (2015). This might be because our study examined ICU patients, while most of their cases were from general wards. In addition, despite the lack of statistical significance, the patients with pneumonia-related ABC bacteremia in our study had a higher rate of septic shock and low lactate levels, implying that respiratory tract-colonized ABC can invade the blood.

Next, we analyzed patients with different prognoses. In univariate and multivariate analysis, immunosuppression and the APACHE II and SOFA scores at the time of bacteremia were independent risk factors for 30-day mortality in patients with ABC bacteremia. We also found that patients with pneumonia-related ABC bacteremia were more likely to have a poor prognosis, although it was not an independent risk factor for 30-day mortality on multivariate analysis. We reviewed the literature on ABC bacteremia in the last 10 years. In 2019, a systematic review and meta-analysis of 10 eligible studies of 923 patients with ABC bacteremia reported that risk factors for attributable mortality included neutropenia, chronic liver disease, chronic renal failure, steroid therapy, immunosuppressant use, septic shock, severity of illness (as defined by the Pitt bacteremia score), and inappropriate empirical antimicrobial treatment.[9] Three recent studies all found that a high Pitt bacteremia score was an independent risk factor for ABC bacteremia-related mortality.[8,10,24] Moreover, Zhou et al and Park et al showed that bacteremia occurring after pneumonia was an independent risk factor for death, while the results of Gu et al and our study countered this conclusion. Kim et al and Yu et al all showed that catheter-related infection and early colistin therapy were independent favorable prognostic factors associated with 28-day mortality in patients with CR *Acinetobacter baumannii* bacteremia.[12,25] Liat et al found that, to be a protective factor, appropriate antibiotic therapy must be strarted within 48 hours.[14] All of these studies had very small sample sizes, so larger studies are required to confirm our findings.

The effective management of sepsis and septic shock should focus on timely intervention, including removal of infection source, early initiation of appropriate antimicrobial therapy, fluid resuscitation, and resolution of organ dysfunction.[26] CR *Acinetobacter baumannii* bacteremia is resistant to the currently used antibiotics, except for tigecycline and polymyxin. Kim et al found that early colistin therapy can reduce the mortality of septic shock patients with CR *Acinetobacter baumannii* bacteremia.[25] Among antibiotic strategies, Son et al showed that colistin combined with tigecycline or other antibiotics was significantly associated with lower mortality after adjusting for confounding factors,[11] which differed from Lee et al.[27] For physicians who lack clinical experience, starting appropriate antimicrobial therapy at the time of bacteremia is very difficult because of bacterial resistance. We found no significant difference in appropriate treatment rates between survivors and those who died. We also found that immunosuppression and illness severity, as defined by the APACHE II and SOFA scores, were significantly associated with higher mortality. Similar results were reported by Lim et al suggested that host factors and severity of infections reflected by APACHE are the main determinants of the outcome rather than the use of active antimicrobial therapy.[28] Therefore, further research needs to determine whether inactive microbial therapy can improve outcomes.

Our study has some limitations. Its main limitation was the small number of ABC bacteremia patients, which decreased the power of our statistical analyses. Second, the study used a retrospective, observational, single-venter design, potentially limiting the generalizability of our results to other hospitals. Further randomized controlled trials with larger sample sizes and multicenter designs are required. Third, since this study was retrospective, the completeness of data may be deficient leading to the misclassification bias. Fourth, we could not determine whether the virulence of ABC strains changed significantly over time.

CONCLUSIONS

In short, our study found that the number of patients with ABC bacteremia has decreased over the past 5 years, but the proportion of CR ABC is very high. Patients with pneumonia-related ABC bacteremia had a higher rate of hypertension, less prior tigecycline use, more CR strains, and a higher 30-day mortality rate. Our results also suggest that immunosuppression and higher APACHE II and SOFA scores were risk factors of 30-day mortality. We believe that the clinicians should pay more attention to patient's immune status and the severity of the disease to improve the prognosis.

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