Non-PSEUDO-AntiBiotiCs Score—A Predictor of Bacteraemia Caused by *Pseudomonas aeruginosa*: A Case-control Study

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Abstract

Background: Immoderate use of broad-spectrum antimicrobials could lead to emergence of resistant bacteria. The purpose of this study was to identify factors associated with *Pseudomonas aeruginosa* bacteraemia and develop an exclusion scoring system to help clinicians select an appropriate antimicrobial treatment.

Methods: This single-centre case-control study recruited inpatients and outpatients (age ≥ 20 years) with *P. aeruginosa* or *Escherichia coli* bacteraemia at St. Luke's International Hospital in Tokyo from April 2005 to March 2020. Bivariate associations were assessed using χ^2 test, Fisher's exact test, or Mann–Whitney U test, and the relationship between *P. aeruginosa* bacteraemia and other variables was determined using multivariable logistic regression analysis.

Results: A total of 1562 patients (208 patients with *P. aeruginosa* bacteraemia and 1354 patients with *E. coli* bacteraemia) were included. Multivariable analysis revealed 11 variables associated with *P. aeruginosa* bacteraemia: **N**osocomial infections, **P**neumonia, **S**ex (males), **E**xposure to antibiotics within 90 days, **U**rinary tract infection, **U**rinary catheterization, **a**b**D**ominal infection, **A**ge < 77 years, **B**ody mass index < 19 , presence of **C**entral venous catheter, and **C**entral line-associated bloodstream infection/peripheral line-associated bloodstream infection; these variables were used to develop the **Non-PSEUDO-AntiBiotiCs** score. The area under the receiver operating characteristic curve was 0.89 (95% confidence interval: 0.88–0.92), and the best cut-off-point was 5; a score of ≥ 5 had a sensitivity of 80% and a specificity of 83%.

Conclusion: We developed the Non-PSEUDO-AntiBiotiCs score. This score may allow clinicians to rule out the possibility of *P. aeruginosa* bacteraemia and prevent the abuse of broad-spectrum antimicrobials.

Background

Pseudomonas aeruginosa bacteraemia (PAB) has a higher mortality rate (29%) [1] than bacteraemia caused by other gram-negative rods, such as *Escherichia coli* and *Klebsiella* spp. [2]. *P. aeruginosa* is an innately antibiotic-resistant microorganism, and its toxicity mechanisms have been shown to be associated with restricted permeability of the cell wall, enhanced activity of the efflux system, and presence of the ampC gene for inducible chromosome beta-lactamase [3]. Empiric antimicrobial treatment failure is known to result in higher mortality rates in both community-acquired and nosocomial infections [4]. Therefore, clinicians often need to determine whether *P. aeruginosa* is a causative organism based on previously reported risk factors.

Notably, the abuse of broad-spectrum antimicrobials for treating *P. aeruginosa* could lead to emergence of resistant bacteria and an increase in adverse events [5]. Because inadequate empirical treatment is related to all-cause mortality and infection-related mortality due to PAB [1], appropriate and prompt antimicrobial treatments are essential for the management of PAB. Risk factors for PAB have already been identified and include male sex [1, 6, 7], haemodialysis [1, 7], solid organ transplants [1], cancer [1],

human immune deficiency virus infection [1], diabetes [8], neutropenia [6, 7, 9], haematological malignancy [7, 9, 10], central venous catheter [11, 12], healthcare-associated infection [7, 11], prior hospital admission [7], and prior antimicrobial use [12, 13]. Although these factors are useful for suspecting the presence of PAB, to the best of our knowledge, no scoring systems are available to help clinicians rule out the possibility of PAB. Therefore, the purpose of this study was to identify factors associated with PAB and develop an exclusion score system that will assist in clinical practice.

Methods

Study Aim and Design

This study aimed to identify factors associated with *Pseudomonas aeruginosa* bacteraemia and develop an exclusion scoring system to help clinicians select an appropriate antimicrobial treatment. A retrospective, single-centre, case-control study was performed at St. Luke's International Hospital (a 520-bed hospital) in Tokyo, Japan, between April 2005 and March 2020.

Inclusion and Exclusion Criteria

Inpatients and outpatients (age ≥ 20 years) with PAB or *E. coli* bacteraemia (ECB) were selected from the electronic hospital database based on positive blood culture findings. Patients with *E. coli* detected by blood culture during the corresponding period were included in the control group, and those with multiple bacteraemias were excluded. In addition, in patients with multiple episodes of bacteraemia, only the first episode of bacteraemia was included in the analysis.

Data Collection

Patient data were extracted from inpatients' and outpatients' electronic medical records. Study variables included patient demographics, comorbidities, probable causes of bacteraemia, presence of foreign bodies, use of immunosuppressive drugs, chemotherapy, antibiotics within 90 days before bacteraemia, hospitalization within 1 year, surgery within 1 year, vital signs, laboratory results and microbiological findings, length of stay, admission to the intensive care unit, and mortality.

Variable Definitions

PAB and ECB were defined by the laboratory findings of at least one set of positive blood cultures collected using standard sterile techniques [11]. Neutropenia was defined as a neutrophil count of less than $500/\text{mm}^3$ [8]. The source of bacteraemia was comprehensively determined through a review of the electronic discharge summary and the daily chart record of patient symptoms, physical examinations, laboratory results, and radiological findings. A central venous catheter, such as a central venous port catheter, peripherally inserted central catheter, or temporary or permanent catheter for haemodialysis, was defined as an intravascular access device or a catheter whose end is placed in or near the heart or in one of the main veins [8, 14, 15]. Malignancies included both solid tumours and hematologic malignancies that had been treated with chemotherapy within the last 90 days. Central line-associated bloodstream

infection (CLABSI) was classified as an infection of central venous catheters and peripherally inserted central venous catheters using the Centres for Disease Control and Prevention definitions [16], and peripheral line-associated bloodstream infection (PLABSI) was defined as bacteraemia with at least one of the following criteria: existence of phlebitis and/or disappearance of clinical symptoms after peripheral line withdrawal, and/or careful exclusion of bacteraemia as another focus [17, 18]. Intra-abdominal infections included cholangitis, cholecystitis, intestinal obstruction, oesophageal varices, appendicitis, diverticulitis, peritonitis, liver abscess, intra-abdominal abscess, and acute pancreatitis. Skin and soft tissue infections included erysipelas, cellulitis, subcutaneous abscess, necrotizing fasciitis, and wound infections. Respiratory diseases included chronic obstructive pulmonary disease (COPD), asthma and COPD overlap syndrome, bronchiectasis, interstitial pneumonia, diffuse panbronchiolitis, and bronchial asthma. Nosocomial infections (healthcare-associated infections) were diagnosed when patients had a positive blood culture after 48 hours of hospitalization. Community-acquired bacteraemia was diagnosed when it occurred in the outpatient setting or within 48 hours of hospitalization; however, patients who fulfilled one or more of the following criteria were categorized as having healthcare-associated infections [11, 19]: 1) underwent intravenous therapy at home or in an outpatient setting within the past 30 days; 2) attended a hospital, haemodialysis clinic, or received intravenous chemotherapy within the past 30 days; 3) had more than two days of hospitalization in the past 90 days; and 4) spent two or more days in a nursing home or in an assisted living facility in the past 90 days.

Microbiological Tests

We used the BacT/ALERT 3D system (bioMérieux, Inc.) for blood cultures and the MicroScan WalkAway 96PLUS (Beckman Coulter, Tokyo, Japan) for susceptibility testing.

Statistical Analyses

In bivariate associations, we used the chi-square or Fisher's exact test for categorical variables and the Mann–Whitney U test for continuous variables. Variables significantly associated with PAB in univariate analysis were applied to the CART model as a part of the multivariable analysis after removing highly correlated explanatory variables in terms of the variance inflation factor for multicollinearity. For continuous variables, those that were statistically significant in univariate analysis were converted into binary categorical variables using the CART model. As a result, variables that appeared at higher branch levels in the tree of the CART model and those that were clinically important among variables that were statistically significant in univariate analysis were included as explanatory variables in the multivariate logistic regression analysis. The final explanatory variables of the model were selected by the forward stepwise approach. The receiver operating characteristic (ROC) curve was plotted with the model, and the values of the cut-off-point and area under the ROC curve were calculated from this ROC curve.

The statistical significance threshold was set at $P < 0.05$. All statistical analyses were carried out using the statistical software program SPSS 19.0J (IBM Japan, Tokyo, Japan) and EZR (Saitama Medical Center, Jichi Medical University, Saitama, Japan), which is a graphical user interface for R (The R Foundation for Statistical Computing, Vienna, Austria).

Results

Study Participants

Of the 1592 observations, 14 observations (7 patients with both PAB and ECB) were excluded, and the first episodes of bacteraemia of 16 patients with multiple episodes of bacteraemia were included. Ultimately, 1562 patients (208 PAB and 1354 ECB) were included in the study (Fig. 1). Comparisons of demographic characteristics, comorbidities, and site of infection between the PAB and ECB groups are shown in Table 1. Patients with PAB were younger (72 years versus 76 years, $p < 0.001$) and less obese (19.7% versus 21.7, $p < 0.001$) and had higher proportions of males (68.3% versus 40.5%; $p < 0.001$), solid tumours (11.1% versus 7.0%; $p = 0.048$), haematological malignancy (5.3 % versus 2.1%; $p = 0.013$), diabetes (37.0% versus 28.7%; $p = 0.018$), chronic kidney disease (12.5% versus 7.8%; $p = 0.030$), haemodialysis (12.5% versus 4.5%; $p < 0.001$), and neutropenia (5.8% versus 1.6%; $p = 0.001$) than those with ECB. In addition, the PAB group had higher percentages of urinary catheters (65.4 % versus 22.7%; $p < 0.001$), central venous catheter (38.5% versus 9.7%; $p < 0.001$), peripherally inserted central venous catheter (PICC) (4.8% versus 1.9%; $p = 0.021$), and arterial line (31.7% versus 9.2%; $p < 0.001$) than the ECB group.

Table 1

Comparison of patient characteristics between *Pseudomonas aeruginosa* and *Escherichia coli* bacteraemia groups using univariate analysis

	<i>P. aeruginosa</i> (n = 208)	<i>E. coli</i> (n = 1354)	p values
Age, median (IQR)	72 (60–79.8)	76 (64–84)	< 0.001
Sex (male), n (%)	142 (68.3)	548 (40.5)	< 0.001
BMI, median (IQR)	19.7 (17.4–22.7)	21.7 (19–24.3)	< 0.001
Comorbid conditions, n (%)			
Solid tumour	23 (11.1)	95 (7.0)	0.048
Haematological malignancy	11 (5.3)	28 (2.1)	0.013
Diabetes mellitus	77 (37.0)	388 (28.7)	0.018
Chronic kidney disease	26 (12.5)	105 (7.8)	0.030
Haemodialysis	26 (12.5)	61 (4.5)	< 0.001
Peritoneal dialysis	1 (0.5)	3 (0.2)	0.436
Neutropenia	12 (5.8)	22 (1.6)	0.001
Respiratory disease	30 (14.4)	172 (12.7)	0.505
Predisposing condition, n (%)			
Urinary catheterization	136 (65.4)	308 (22.7)	< 0.001
Presence of central venous catheter	10 (25)	14 (24.1)	< 0.001
Presence of peripherally inserted central venous catheter	10 (4.8)	26 (1.9)	0.021
Arterial line	66 (31.7)	124 (9.2)	< 0.001
Venous line	175 (84.1)	518 (38.3)	< 0.001
Use of a mechanical ventilator	30 (14.4)	49 (3.6)	< 0.001
Tracheal intubation	30 (14.4)	38 (2.8)	< 0.001
Primary site of infection (source of bacteraemia), n (%)			
Urinary tract infection	67 (32.2)	881 (65.1)	< 0.001
Abbreviations: IQR, interquartile range; BMI, body mass index; CLABSI, central line-associated bloodstream infection; PLABSI, peripheral line-associated bloodstream infection; SpO ₂ , oxygen saturation measured by a pulse oximeter; γ-GTP, γ-glutamyl transpeptidase; CRP, C-reactive protein.			

	<i>P. aeruginosa</i> (n = 208)	<i>E. coli</i> (n = 1354)	p values
Abdominal Infection	35 (16.8)	335 (24.7)	0.016
Pneumonia	67 (32.2)	36 (2.7)	< 0.001
CLABSI/PLABSI	13 (6.3)	3 (0.2)	< 0.001
Skin and soft tissue	5 (2.4)	9 (0.7)	0.037
Unknown and others	21 (10.1)	90 (6.6)	0.097
Drug use within the prior 90 days, n (%)			
Steroid	72 (34.6)	189 (14.0)	< 0.001
Chemotherapy	34 (16.3)	123 (9.1)	0.003
Antibiotics	172 (82.7)	372 (27.5)	< 0.001
Hospitalization within the prior 1 year, n (%)	78 (37.5)	392 (29.0)	0.015
Surgery within the prior 1 year, n (%)	89 (42.8)	221 (16.3)	< 0.001
Nosocomial, n (%)	149 (71.6)	431 (31.8)	< 0.001
Vital signs, median (IQR)			
Systolic blood pressure (mmHg)	120 (104–135)	120 (102–138)	0.908
Pulse rate (/minute)	90 (78–108)	88 (76–102)	0.173
Respiratory rate (/minute)	18 (16–24)	18 (16–23.25)	0.065
Temperature (°C)	37.3 (36.7–38.3)	37.7 (36.8–38.6)	0.003
Oxygen saturation (%)	97 (95–98)	96 (95–98)	0.042
Laboratory findings, median (IQR)			
White blood cell count ($\times 10^3/\mu\text{L}$)	9.85 (6.2–15.1)	10.5 (7–14.4)	0.291
Albumin (g/dL)	2.85 (2.3–3.4)	3.4 (2.9–3.8)	< 0.001
Total bilirubin (mg/dL)	0.7 (0.4–1.1)	0.8 (0.6–1.5)	< 0.001
γ -GTP (U/L)	67 (29.5–162.5)	48 (22–148.5)	0.019
Creatine kinase (U/L)	50 (26–112.5)	67 (38–136.8)	0.001

Abbreviations: IQR, interquartile range; BMI, body mass index; CLABSI, central line-associated bloodstream infection; PLABSI, peripheral line-associated bloodstream infection; SpO₂, oxygen saturation measured by a pulse oximeter; γ -GTP, γ -glutamyl transpeptidase; CRP, C-reactive protein.

	<i>P. aeruginosa</i> (n = 208)	<i>E. coli</i> (n = 1354)	p values
Calcium (mg/dL)	8.4 (7.7–8.9)	8.8 (8.4–9.2)	< 0.001
Potassium (mmol/L)	4 (3.7–4.6)	3.9 (3.5–4.3)	< 0.001
CRP (mg/dL)	6.08 (2.4–12.5)	8.07 (2.9–16.2)	0.020
Haemoglobin (g/dL)	10.25 (8.8–12.0)	11.8 (10.2–13.2)	< 0.001
Platelet ($\times 10^3/\mu\text{L}$)	197 (119–275)	174 (126–226)	0.016
Blood sugar (mg/dL)	120 (97.8–159.3)	129 (106–162)	0.019
Length of stay in the hospital, median (IQR)	37 (20–92.5)	13 (8–27)	< 0.001
Admission to ICU, n (%)	46 (22.1)	172 (12.7)	< 0.001
30-day mortality, n (%)	44 (21.2)	117 (8.6)	< 0.001
90-day mortality, n (%)	69 (33.2)	177 (13.1)	< 0.001
Abbreviations: IQR, interquartile range; BMI, body mass index; CLABSI, central line-associated bloodstream infection; PLABSI, peripheral line-associated bloodstream infection; SpO ₂ , oxygen saturation measured by a pulse oximeter; γ -GTP, γ -glutamyl transpeptidase; CRP, C-reactive protein.			

Regarding the sources of bacteraemia, pneumonia (32.2% vs. 2.7%; $p < 0.001$), CLABSI/PLABSI (6.3% vs. 0.2%; $p < 0.001$), and skin and soft tissue infections (2.4% vs. 0.7%; $p = 0.037$) were significantly more commonly seen in the PAB group than in the ECB group. The PAB group had higher percentages of a history of hospitalization (37.5% vs. 29.0%; $p = 0.015$) and surgery (42.8% versus 16.3%; $p < 0.001$) and recent usage of steroids (34.6% versus 14.0%; $p < 0.001$), chemotherapy (16.3% versus 9.1%; $p = 0.003$), and antibiotics (82.7% versus 27.5%; $p < 0.001$) than the ECB group.

The independent associated factors for PAB that were revealed in the multivariable analysis were as follows: nosocomial infection (OR = 1.84, 95% CI = 1.2–2.8; $p = 0.006$), pneumonia (OR = 4.2, 95% CI = 1.92–9.11; $p < 0.001$), sex (males) (OR = 2.48, 95% CI = 1.64–3.76; $p < 0.001$), exposure to antibiotics within 90 days (OR = 4.4, 95% CI = 2.64–7.46; $p < 0.001$), urinary catheterization (OR = 2.01, 95% CI = 1.27–3.19; $p = 0.003$), age < 77 years (OR = 1.69, 95% CI = 1.11–2.59; $p = 0.015$), body mass index (BMI) < 19 (OR = 2.42, 95% CI = 1.61–3.64; $p < 0.001$), presence of central venous catheter (OR = 2.42, 95% CI = 1.11–3.0; $p = 0.018$), and CLABSI/PLABSI (OR = 15.3, 95% CI = 3.09–75.6; $p < 0.001$) (Table 2). In addition, urinary tract infection (OR = 0.34, 95% CI = 0.18–0.65; $p = 0.001$) and abdominal infection (OR = 0.47, 95% CI = 0.23–0.96; $p = 0.039$) were sources of bacteraemia negatively associated with PAB (Table 2).

Table 2

Results of the multivariable logistic regression analysis used to determine the Non-PSEUDO-AntiBiotiCs score.

	Adjusted OR	Beta coefficient	95% CI	p values	Points
Nosocomial	1.84	0.61	1.2–2.8	0.006	1
Pneumonia	4.2	1.43	1.92–9.11	< 0.001	3
Sex (male)	2.48	0.91	1.64–3.76	< 0.001	2
Exposure to antibiotics within 90 days	4.4	1.49	2.64–7.46	< 0.001	3
Urinary tract infection	0.34	–1.1	0.18–0.65	0.001	–2
Urinary catheterization	2.01	0.70	1.27–3.19	0.003	1
AbDOminal Infection	0.47	–0.75	0.23–0.96	0.039	–1
Age < 77	1.69	0.53	1.11–2.59	0.015	1
BMI < 19	2.42	0.88	1.61–3.64	< 0.001	2
Presence of Central venous catheter	1.82	0.60	1.11–3.0	0.018	1
CLABSI/PLABSI	15.3	2.73	3.09–75.6	< 0.001	5

To develop a prediction system for PAB, we focused on the beta coefficients corresponding to the variables that were statistically significant in the multivariable analysis. We calculated the weight scores by dividing each beta coefficient by the smallest value among the absolute beta coefficients and rounding the divided beta coefficients to develop the understandable rule. The obtained weight scores (Non-PSEUDO-AntiBiotiCs score) are shown as follows: **Nosocomial** (1 point); **Pneumonia** (3 points); **Sex** (males, 2 points); **Exposure to antibiotics within 90 days** (3 points); **Urinary tract infection** (–2 points); **Urinary catheterization** (1 point); **abDOminal infection** (–1 point); **Age < 77 years** (1 point); **BMI < 19** (2 points); **presence of Central venous catheter** (1 point); and **CLABSI/PLABSI** (5 points).

In the final analysis, the area under the ROC curve was 0.89 (95% CI: 0.88–0.92) (Fig. 2), and the best cut-off point was 5. A score of 5 or higher had a sensitivity of 80%, a specificity of 83%, a positive predictive value of 42%, and a negative predictive value of 96%.

Discussion

To the best of our knowledge, this study is the first to develop a clinically predictive (exclusion) score for PAB, “Non-PSEUDO-AntiBiotiCs score”, using 11 elements that were significantly different in multivariable analysis. Males, age < 77 years, BMI < 19, placement of the urinary catheter, indwelling central venous catheter, nosocomial infection, use of antibiotics within 90 days, pneumonia, and CRBSI as a source of bacteraemia were independent associated factors for PAB, and the probability of PAB tended to be low if the score was less than 5. The current study differs from previous studies in that it included larger sample size and provided a simple and useful prediction score in the clinical setting. This scoring system would help clinicians select empirical antibacterial therapy.

It is often difficult for clinicians to decide whether *P. aeruginosa* should be considered in the setting of suspected community-acquired and nosocomial infections, such as pneumonia, urinary tract infection, and intra-abdominal infections. While the failure of empirical treatment in patients with PAB has already been shown to increase the mortality rate [20], abuse of broad-spectrum antimicrobial agents could lead to multidrug-resistant bacteria [5] and increase adverse events, such as *Clostridium difficile* infections [21], thereby resulting in longer hospital stays and additional costs [22]. Therefore, it is important to select appropriate empirical antimicrobials based on patients' risk factors and clinical findings.

Two previous large studies determined the risk factors for PAB using ECB as a control group and found that an indwelling central venous catheter (CVC) [11], neutropenia [11], presentation with septic shock [11], healthcare-associated infection [11], and respiratory tract infection [8] were independent risk factors. Similarly, the present study also showed that the presence of CVC and respiratory infection were independent factors for PAB [8, 13]. In addition, urinary tract infection was found to be one of the negative factors for PAB; this finding is consistent with that in a previous study [8].

In comparison to findings in previous studies, one of the new independent associated factors identified in this study was CLABSI/PLABSI. This result could be explained by the fact that *P. aeruginosa* is the most common gram-negative rod causing CLABSI/PLABSI, while *E. coli* is relatively rare [23, 24]. A previous study showed the above trend, but the finding was not statistically significant [11]. The larger sample size might have contributed to the significant findings in this present study. The current study also showed that BMI < 19 was an associated factor for PAB. Because this study was a cross-sectional study, it is unclear whether low BMI is a cause or a consequence of PAB; however, *P. aeruginosa* infection could be a cause of emaciation because chronic infection with *P. aeruginosa* has been reported to produce pyocyanin, which leads to weight loss [25]. In addition, patients with chronic underlying diseases, such as bronchiectasis and cancer, may develop malnutrition [26, 27]. These patients may have contracted *P. aeruginosa* infection during their medical treatment in hospitals. Moreover, the findings of other significant associated factors, including age, male sex [1, 6, 7], exposure to antibiotics [12, 13], and urinary catheterization [12], are consistent with those in previous studies. However, it is possible that some hidden confounding factors could not be identified in the present retrospective study since it

addressed only cases of recent hospitalization for a period of less than one year, and this could be an issue for future studies.

Since delays in treatment of PAB are known to be associated with increased mortality [1, 20], early prediction of PAB may contribute to patients' clinical outcomes. Our scoring system may help clinicians determine whether *P. aeruginosa* should be considered a causative pathogen of infection. Moreover, the use of this scoring system may reduce unnecessary broad-spectrum antimicrobial use, thereby preventing the emergence of multidrug-resistant bacterial pathogens.

This study has several limitations. First, this study was performed at a single institution, and the sample size was relatively small. Second, this was an observational study; thus, it is possible that unknown risk factors were distributed unequally between the two groups. Third, this study included only patients with positive blood cultures. Therefore, this scoring system cannot be applied to all patients with negative blood cultures. Since it is often unclear whether bacteraemia is present in the early onset of the disease, this scoring system should be interpreted expansively and judged carefully together with clinical information. Fourth, this scoring system cannot be used if the source of infections remains unknown at the time of diagnosis because clinicians need to use the source of infection to calculate the score.

Conclusion

We developed the Non-PSEUDO-AntiBiotiCs score. This scoring system may allow clinicians to rule out the possibility of *P. aeruginosa* bacteraemia and optimize the use of broad-spectrum antimicrobials.

List Of Abbreviations

CLABSI, Central line-associated bloodstream infection; COPD, chronic obstructive pulmonary disease; CVC, central venous catheter; ECB, *E. coli* bacteraemia; PAB, *Pseudomonas aeruginosa* bacteraemia; PLABSI, peripheral line-associated bloodstream infection; ROC, receiver operating characteristic.

Declarations

Ethics approval and consent to participate:

The research protocol of this study was approved by the Facility Review Committee of St. Luke's International Hospital, Tokyo (number: 20-J001). This study was conducted in accordance with the Declaration of Helsinki and followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines. Because this study is based on a retrospective analysis of the routinely obtained data, the requirement for patient agreement was waived by the Facility Review Committee of St. Luke's International Hospital.

Consent for publication:

Not applicable

Availability of data and materials:

The datasets used and analysed during the current study available from the corresponding author on reasonable request.

Competing interests:

The authors declare that they have no competing interests.

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Author contributions:

All authors contributed to the study conception and research design. KI compiled and synthesized the data and drafted the first version of the manuscript. TM, KH, and NM contributed to the writing of the manuscript. KI and KH conducted the statistical analysis. All authors were responsible for interpreting the results and approved the final version of the manuscript.

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Figures

Figure 1

Study design Of the 1592 observations, 14 observations (7 patients with both PAB and ECB) were excluded, and the first episodes of bacteraemia of 16 patients with multiple episodes of bacteraemia were included. Consequently, 1562 patients (208 PAB and 1354 ECB) were included in the study. Abbreviations: *P. aeruginosa*, *Pseudomonas aeruginosa*; *E. coli*, *Escherichia coli*; PAB, *Pseudomonas aeruginosa* bacteraemia; ECB, *E. coli* bacteraemia.

Figure 2

The receiver operating characteristic curve of the Non-PSEUDO-AntiBiotiCs score In the final analysis, the area under the receiver operating characteristic curve was 0.89 (95% CI: 0.88-0.92), and the best cut-off point was 5. A score of 5 or higher had a sensitivity of 80%, a specificity of 83%, a positive predictive value of 42%, and a negative predictive value of 96%.