

Prognostic Value of Alactic Base Excess for 28 Day Mortality in Sepsis Patients: A Retrospective Prognostic Accuracy Study in an Intensive Care Unit

Paulus Sulistiono,^{1,2} Reza Widiyanto Sudjud², Dhany Budipratama²

¹Hermina Hospital Karawang, Indonesia

²Department of Anesthesiology and Intensive Care, Faculty of Medicine Universitas Padjadjaran
Dr. Hasan Sadikin General Hospital Bandung, Indonesia

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Corresponding Author:
Paulus Sulistiono
Hermina Hospital Karawang,
Indonesia
E-mail:
paulusmukri@gmail.com

Abstract

Introduction: Prognostication in sepsis is challenging. Serum lactate is widely used but cannot separate non-lactate contributions to metabolic acidosis. Alactic Base Excess (ABE) provides a more complete assessment of acid–base status. This study assessed ABE’s value in predicting 28-day mortality in sepsis patients.

Methods: A retrospective study included 109 adult sepsis patients meeting Sepsis-3 criteria with arterial blood gas analysis within 24 hours of ICU admission. ABE was calculated from base excess and lactate. Prognostic performance was evaluated using ROC analysis, and association with mortality was assessed using odds ratios (OR).

Results: Of 109 patients, 59 (54.1%) died within 28 days. Non-survivors had more negative median ABE than survivors (-7.04 vs. -0.15; $p < 0.001$). Optimal ABE cut-off was ≤ -4.1 . Patients with $ABE \leq -4.1$ had a higher risk of mortality (OR 38.6; 95% CI: 13.2–112.9; $p < 0.001$).

Discussion: ABE showed strong prognostic performance, reflecting non-lactate metabolic acidosis not captured by lactate alone. As it is derived from routine arterial blood gas analysis, ABE is practical for early risk stratification in critically ill sepsis patients.

Conclusion: ABE demonstrates excellent prognostic value for 28-day mortality in ICU sepsis patients. An $ABE \leq -4.1$ is linked to significantly higher mortality and may serve as a readily available biomarker for early risk assessment and timely clinical decisions.

Keywords: Alactic base excess; Intensive Care Unit; mortality; prognosis; sepsis

Introduction

Sepsis is life-threatening organ dysfunction due to a dysregulated host response to infection.¹ According to the Global Burden of Disease study, sepsis accounts for approximately 11 million deaths annually, representing nearly one-fifth of all global deaths.¹ In Asia, a 2019 study across 386 ICUs in 22 countries reported a sepsis prevalence of 22.4%.² Although specific epidemiological data from Indonesia

remain unpublished, as a lower-middle-income country, the burden and prevalence of sepsis are presumed to be high.³

Serum lactate measurement has long been used as a prognostic indicator in sepsis, where lactate levels >4 mmol/L are associated with a survival rate of only 11% after 24 hours of ICU care.⁴ An elevated lactate level has multiple causes, such as metabolic stress or liver dysfunction, not just tissue hypoxia. Therefore, a high reading alone does not

confirm oxygen deficiency at the cellular level, nor does it account for other acids that may be contributing to acidosis.⁶ In this context, Alactic Base Excess (ABE) has emerged as a promising parameter, combining standard base excess and lactate values to assess overall acid-base status and the blood's buffering capacity, and showing a significant correlation with renal function ($r = -0.36$; $p < 0.0001$).⁴

This study aimed to examine the relationship between Alactic Base Excess (ABE) and patient outcomes by comparing ABE values between survivors and non-survivors of sepsis in the intensive care unit. The analysis sought to determine whether more negative ABE values were associated with higher mortality, thereby assessing the potential of ABE as a prognostic marker in sepsis.

Subjects and Methods

This study employed a retrospective analytical design with a prognostic accuracy approach, utilizing data from the intensive care unit (ICU) registry of Dr. Hasan Sadikin General Hospital, Bandung. The registry routinely identifies sepsis patients based on the Sepsis-3 criteria as part of the infection team's admission protocol.⁷ All adult patients aged 18 to 65 years with a confirmed diagnosis of sepsis between January and December 2025 were screened. Only those whose arterial blood gas analysis within the first 24 hours of ICU admission included both lactate and base excess values were eligible. Patients with malignancy, congenital metabolic disorders, metformin use within 24 hours before measurement, carbon monoxide poisoning, recent seizures or strenuous activity within 6 hours before measurement, high-dose epinephrine administration, end-stage liver cirrhosis, or chronic kidney disease were excluded.

A minimum sample size of 108 subjects was calculated based on prognostic AUC testing parameters ($\alpha = 0.05$, $\beta = 0.05$, minimum AUC = 0.70, $\Delta AUC = 0.20$), with an anticipated dropout rate of 10%. From the eligible population, 109 patients were randomly selected using a computer-generated random number

application to meet the sample requirement. Patients were categorized according to their 28-day in hospital outcomes as survivors or non-survivors. Patients discharged before completion of the 28-day observation period were considered dropouts and excluded from the analysis. Admission Alactic Base Excess (ABE) values were derived from arterial blood gas analysis within the first 24 hours of ICU admission included lactate and standard base excess measurements and compared between groups to determine the association between ABE and mortality.

Ethical approval was granted by the Ethics Committee of Dr. Hasan Sadikin General Hospital (No. DP.04.03/XIV.6.5/209/2025). Data analysis was performed using SPSS version 26.0. Continuous variables were summarized as median (interquartile range) and compared using the unpaired t-test or Mann-Whitney U test as appropriate, while categorical variables were analyzed using the chi-square or Fisher's exact test. Receiver operating characteristic (ROC) curve analysis was used to assess the discriminative ability of ABE and to determine the optimal cut-off value, along with sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy. Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated to estimate the strength of association between ABE and mortality. A $p\text{-value} \leq 0.05$ was considered statistically significant.

Results

This study involved 109 patients diagnosed with sepsis whose baseline characteristics are presented in Table 1. Subjects had a median age of 53 years, with a gender composition of 66 male patients (60.6%) and 43 female patients (39.4%). Laboratory parameters showed a median lactate of 1.60, BE -2.80, pH 7.40, HCO₃ 19.40, SBE -4.79, and Alactic BE -3.24.

Comparative analysis of characteristics between groups that died and survived using

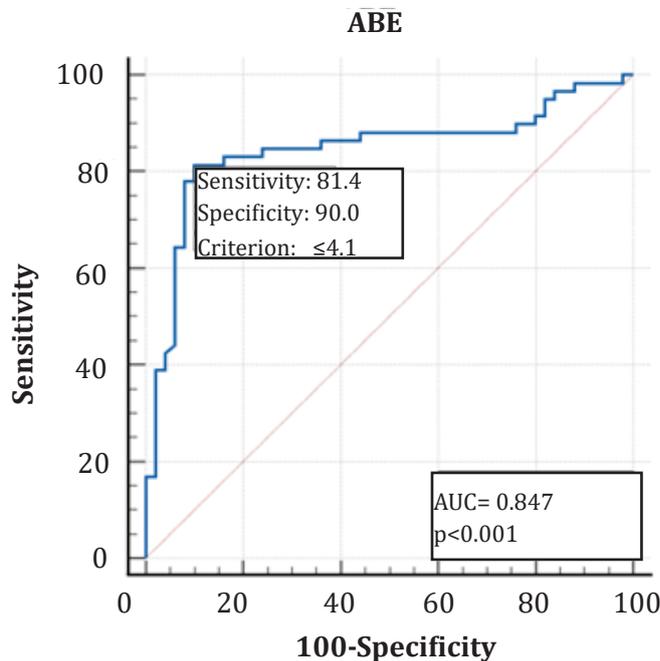


Figure 1 ROC Curve

the t-test for normally distributed data (age) and the *Mann-Whitney* test for non-normally distributed data (biochemical parameters). The results showed no significant difference in age ($p=0.807$) and gender ($p=0.143$) between the two groups. However, there were statistically significant differences in lactate, BE, pH, HCO_3 , and SBE values with $p<0.001$, as presented in Table 1.

Alactic Base Excess demonstrated a highly significant difference between the two groups ($p=0.0001$), with a median of -7.04 in the mortality group and -0.15 in the survival group, as presented in Table 3.

The principal findings of this study demonstrate that ABE exhibits excellent prognostic capability. The ROC curve analysis revealed that ABE possesses optimal prognostic value, as evidenced by the curve's deviation from the 50% reference line and approach toward 100%. The area under the curve (AUC) was 84.7% with a p-value of 0.001 based on one-sample Z-test, indicating that ABE is statistically significant as a robust and reliable predictor for distinguishing sepsis patients with high and low mortality risk.

The 95% confidence interval for the ABE AUC ranged from 76.5% to 90.8%. The optimal cut-off point for ABE was ≤ -4.1 , yielding a sensitivity of 81.4% and specificity of 90.0%. Additional diagnostic test parameters demonstrated a positive predictive value of 90.6%, negative predictive value of 80.4%, and overall accuracy of 85.3%.

To further quantify the predictive strength of ABE, patients were categorized into exposure groups based on the optimal cut-off value ($\text{ABE} \leq -4.1$ vs. $\text{ABE} > -4.1$). As presented in Table 4, among the 53 patients with $\text{ABE} \leq -4.1$, 48 patients (90.6%) died. In contrast, among the 56 patients with $\text{ABE} > -4.1$, 45 patients (80.4%) survived. Binary logistic regression analysis demonstrated that patients with $\text{ABE} \leq -4.1$ had significantly higher odds of 28-day mortality, with an OR of 38.6 (95% CI: 13.2 to 112.9; $p<0.001$), compared to those with $\text{ABE} > -4.1$.

Proportion analysis using chi-square test revealed a significant association between the ABE cut-off and mortality incidence ($p<0.001$). Among 48 patients with ABE values ≤ -4.1 , 81.4% experienced mortality, whereas among

Table 1 Baseline Characteristics of Study Patients

Variable	n=109
Age	
Median	53
Range (min-max)	18-65
Gender	
Male	66 (60.6%)
Female	43 (39.4%)
Lactate	
Median	1.60
Range (min-max)	0.60-9.50
BE	
Median	-2.80
Range (min-max)	-24.80-12.60
pH	
Median	7.40
Range (min-max)	6.83-7.58
HCO ₃	
Median	19.40
Range (min-max)	6.20-37.90
SBE	
Median	-4.79
Range (min-max)	-59.61-13.70
Alactic BE	
Median	-3.24
Range (min-max)	-19.03-14.80

Note: Categorical data are presented as frequencies and percentages, while numerical data are presented as median, minimum, and maximum values

45 patients with values >-4.1 , 90.0% survived, as illustrated in Figure 1.

The sensitivity of 81.4% demonstrates the strong capability of alactic BE to identify patients who will experience mortality, while the specificity of 90.0% indicates excellent capability to identify patients who will survive. The overall accuracy of 85.3% reflects statistically robust diagnostic precision.

Discussion

The median age of 53 years demonstrates that sepsis predominantly affects adult to elderly

populations, with male predominance of 60.6% compared to 39.4% females. This distribution aligns with the retrospective study in US that involving 17,099 sepsis patients in ICUs (median age 67.82 years, 59.7% male) and the prospective study in Nepal (median 44 years, 54.05% male), illustrating regional variations in sepsis epidemiology.^{5,6} The younger mean age compared to developed countries may be influenced by sociodemographic factors and comorbidity patterns in Indonesia.⁸⁻¹⁰

Acid-base parameters showed median lactate 1.60 mmol/L, BE -2.80, pH 7.40, HCO₃⁻ 19.40 mmol/L, SBE -4.79, and ABE -3.24,

Table 2 Comparison of Patient Characteristics Based on Mortality Events

Variable	Mortality Events		p-value
	Non-survivor	Survivor	
	n=50	n=50	
Age			807
Median	52.00	56.00	
Range (min-max)	18.00–65.00	18.00–65.00	
Gender			143
Male	32 (54.2%)	34 (68.0%)	
Female	27 (45.8%)	16 (32.0%)	

Note: Unpaired numerical data were tested using the t-test for normally distributed data, with an alternative *Mann-Whitney* test for non-normally distributed data. Categorical data were analyzed using the *Chi-Square* test with an alternative *Kolmogorov-Smirnov* and *Exact Fisher* test when *Chi-Square* requirements were not met. Statistical significance was set at $p < 0.05$.

indicating mild to moderate metabolic acidosis due to tissue hypoperfusion. This finding is consistent with acid-base manifestations in sepsis reported in previous literature.^{5,11,12}

Negative ABE reflects accumulation of non-lactate strong acids such as organic acids and inflammatory metabolites, making it a potentially superior prognostic biomarker

compared to individual BE or lactate measurements.^{12,13}

Comparative analysis revealed that age and gender did not contribute significantly to mortality ($p > 0.05$), while lactate, BE, pH, HCO_3^- , and SBE parameters differed significantly between non-survivor and survivor groups ($p < 0.05$), confirming the correlation

Table 3 Comparison of ABE Based on Mortality Events

Variable	Mortality Events		p-value
	Yes	No	
	n=59	n=50	
Alactic BE			0.0001**
Median	-7.04	-0.15	
Range (min-max)	-19.03–12.60	-10.90–14.80	

Note: For non-normally distributed data, the Mann-Whitney U test was used; for normally distributed data, an independent t-test was employed. Statistical significance was determined at $p < 0.05$

Table 4 Association between ABE Categories and 28-Day Mortality

Variable	Mortality (n=59)	Survived (n=50)	Total (n=109)	Odds Ratio (OR)	95% Confidence Interval	P-value
ABE \leq -4.1	48 (90.6%)	5 (9.4%)	53	38.6	13.2–112.9	< 0.001
ABE \geq -4.1	11 (19.65%)	40 (80.4%)	56	1.0 (Reference)	-	-

Note: A chi-square test also confirmed a significant association between the ABE category and mortality incidence ($p < 0.001$)

between metabolic acidosis severity and mortality risk.^{14,15} These findings align with previous studies that reported that low BE independently predicts 28-day mortality and supported by a meta-analysis which found significant standardized mean difference in lactate between non-survivors and survivors (standardized mean difference =0.77; 95% CI 0.74–0.79).^{14,16} Elevated lactate indicates a shift toward anaerobic metabolism and hypoperfusion, while decreased BE reflects severe metabolic acidosis correlating with multiple organ dysfunction.

Alactic Base Excess was more negative in non-survivors (median –7.04) compared to survivors (median –0.15) with significant difference ($p < 0.001$), confirming that increasing absolute ABE values correlate with sepsis mortality.¹¹ A U-shaped relationship between ABE and 30-day and 90-day ICU mortality, where both extremely low and high ABE values were associated with increased mortality risk, has also been reported.⁸ The median ABE –4.18 in non-survivors versus –1.10 in survivors ($p < 0.05$), supporting ABE's role as a risk stratification marker.¹¹ Pathophysiologically, ABE reflects accumulation of ketoacids, sulfate, phosphate, and other organic acids due to inflammation and hypoperfusion, serving as an indicator of non-lactate metabolic acidosis in sepsis.⁵

The main findings demonstrated an AUC value of 84.7% (95% CI 76.5%–90.8%; $p = 0.001$) for ABE in distinguishing mortality risk, with optimal cut-off ≤ -4.1 , sensitivity 81.4%, specificity 90.0%, PPV 90.6%, NPV 80.4%, and accuracy 85.3%. The ROC curve's deviation from the 50% diagonal indicates excellent prognostic performance. This performance consistency was also reported, where ABE improved SOFA score accuracy, and demonstrated superior predictive performance compared to BE and lactate.^{5,11}

Given the ease of arterial blood gas examination, ABE warrants consideration for sepsis management protocols in ICUs, particularly for risk stratification and early intervention. Multicenter validation and longitudinal studies are needed to confirm

critical thresholds in heterogeneous populations and evaluate long-term outcomes.

In interpreting these results, several methodological limitations should be acknowledged. First, the retrospective design may introduce selection bias, as only patients with complete arterial blood gas data—specifically those with recorded lactate and base excess values—were included in the analysis. Second, the sample size was relatively small and derived from a single center, which is reflected by the wide confidence interval of the odds ratio and may limit the generalizability of the findings to broader sepsis populations. Third, while ABE was intended to isolate non-lactate metabolic acidosis and minimize confounding from hyperlactatemia, its derivation from base excess and lactate inherently limits its statistical independence from related variables such as pH and standard base excess, potentially introducing multicollinearity if included in multivariate models. Future studies should adopt prospective, multicenter, and multimodal designs, incorporating established clinical predictors such as the SOFA score and distinguishing between surgical and non-surgical sepsis populations. Such an approach would enhance both the external validity and causal interpretability of ABE as a prognostic marker for sepsis mortality.

Conclusion

Nevertheless, despite these limitations, the findings of this study are consistent with multiple international investigations that have demonstrated the strong predictive value of ABE in sepsis outcomes. The statistical analysis in this study reinforces that conclusion, with an AUC of 0.847, sensitivity of 81.4%, specificity of 90.0%, and an odds ratio of 38.6 (95% CI 13.2–112.9; $p < 0.001$), indicating excellent discriminative ability and a robust association between low ABE values and mortality. This alignment with prior evidence supports the reliability and external validity of ABE as a practical, objective, and easily obtainable marker for early prognostic

assessment. Consequently, ABE may serve as a valuable adjunct to clinical judgment and existing scoring systems in guiding timely decision-making and optimizing management strategies in critically ill septic patients.

Use of Artificial Intelligence Statement

Artificial intelligence (ChatGPT, OpenAI, San Francisco, USA) was used in this study solely to assist the authors in refining the structure, academic phrasing, and methodological clarity of the manuscript. The authors verified all content for accuracy, validity, and integrity, and take full responsibility for the scientific conclusions and interpretations presented in this work.

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