e-ISSN: 0976-822X, p-ISSN:2961-6042

Available online on http://www.ijcpr.com/

International Journal of Current Pharmaceutical Review and Research 2026; 18(1); 46-51

Original Research Article

Association of Acid–Base Disturbances with Severity and Outcomes in Sepsis

Vidhi M. Maniya[1], Riya M. Chaudhari[2], Dixit D. Chhatrawala[3]

[1]MBBS, GMERS Medical College, Valsad, Gujarat, India
[2]MBBS, Narendra Modi Medical College, Ahmedabad, Gujarat, India
[3]MBBS, GMERS Medical College, Gandhinagar, Gujarat, India

Received: 14-11-2025 / Revised: 15-12-2025 / Accepted: 01-01-2026
Corresponding Author: Dixit D. Chhatrawala
Conflict of interest: Nil

Abstract:

Background: Complex acid-base and electrolyte abnormalities are prevalent in intensive care units. The blood pH rapidly moves in either of the extreme directions, which can result in serious multi-organ issues, even though in most cases the acid-base changes are small and self-limited.

Objectives: The purpose of the study was to assess the relationship between the severity and clinical outcomes of sepsis patients admitted to the intensive care unit and acid-base abnormalities.

Materials and Methods: It was a retrospective, observational study. The study was carried out at a tertiary care centre. The study data that was retrieved was for one year. Data from 162 participants were retrieved for the study. Included were adult patients with sepsis or septic shock who were hospitalized to the intensive care unit (ICU) and had complete clinical, laboratory, and ABG data at the time of admission.

Results: The largest subgroup consisted of patients with metabolic acidosis, who also had the highest mean SOFA score (9.6 ± 3.2) and the highest percentage of septic shock (58.8%). In a similar vein, patients with a combined acid-base problem had a significantly higher mean SOFA score (8.9 ± 2.8) and a high rate of septic shock (52.9%).

Conclusion: Acid-base imbalances were found to be closely linked to the severity and results of sepsis in this investigation. Compared to patients with normal acid-base status, those with metabolic acidosis and mixed acid-base disorders had far greater rates of septic shock, higher SOFA scores, longer ICU stays, and higher mortality.

Recommendations: Since patients with metabolic acidosis or mixed acid-base abnormalities are more likely to experience septic shock, organ failure, and death, early evaluation and monitoring of acid-base status should be a crucial component of sepsis care.

Keywords: Sepsis, Acid-Base, Alkalosis, SOFA Score, Septic Shock, ABG.

DOI: 10.25258/ijcpr.18.1.9

Introduction

Life-threatening organ failure brought on by a dysregulated host response to infection is known as sepsis [1]. One of the most prevalent and serious illnesses in the intensive care unit (ICU) and a major contributor to ICU patient death is sepsis. Septic shock, which has a relatively high death rate, can develop quickly from sepsis. According to statistics, the death rate from sepsis can be as high as 25–30%, while the death rate from septic shock can be as high as 40% [1, 2].

Improving the prognosis of sepsis patients requires early detection and prompt treatments. Research has demonstrated that fast fluid resuscitation and antibiotic administration during the "golden hour" of sepsis therapy can dramatically lower mortality [3, 4].

According to the Global Burden of Disease Study, there were approximately 48.9 million new cases of sepsis worldwide in 2017, which led to 11 million deaths, or 19.7% of all deaths worldwide [5]. According to a large sample study, 24.4% of cases of sepsis organ failure were acquired during intensive care unit (ICU) hospitalization, and 23.6% of all hospital-treated sepsis cases were hospital-acquired. Hospital-acquired sepsis is a significant public health concern, with a disproportionately high burden on intensive care units [6, 7].

Physicians can treat critically ill patients more effectively if they have a thorough understanding of acid-base imbalance in diverse clinical situations. The severity of the underlying illness that causes morbidity and mortality is reflected in acid-base disorders. Managing issues with hydration, electrolytes, and blood pH takes up a large portion of the work for intensivists [8].

According to one study, 64% of critically sick patients develop severe metabolic acidosis [9]. Complex acid-base and electrolyte abnormalities are prevalent in intensive care units. The blood pH rapidly moves in either of the extreme directions, which can result in serious multi-organ issues, even though in most cases the acid-base changes are small and self-limited. In extreme cases, the normal physiological correction does not occur and self-limitation does not occur [10].

The clinician should be made aware of the potential existence of a significant underlying condition by an acid-base imbalance. Serious underlying metabolic conditions, such as sepsis and uremia, are represented by anion gap acidosis. Conditions like sepsis increase ventilation, which is linked to respiratory acidosis and alkalosis. Mixed metabolic and respiratory diseases, notably metabolic acidosis + respiratory alkalosis, are typically linked to sepsis resulting from neurological, pulmonary, or gastrointestinal causes. On the other hand, metabolic and respiratory acidosis are typically linked to severe pneumonia [11].

The purpose of the study was to assess the relationship between the severity and clinical outcomes of sepsis patients admitted to the intensive care unit and acid-base abnormalities.

Methodology

Study Design: The study was a retrospective, observational.

Study Settings: It was carried out at a tertiary care centre. The study data that was retrieved was for one year.

Study Population: Data of 162 participants were retrieved for the study. Included were adult patients with sepsis or septic shock who were hospitalized to the intensive care unit (ICU) and had complete clinical, laboratory, and ABG data at the time of admission. Patients under the age of eighteen, those with end-stage renal or liver illness, diabetic ketoacidosis, bicarbonate therapy or ventilation prior to ABG, incomplete records, or those who were moved to another intensive care unit after more than twenty-four hours were not included.

Data Collection: Demographics, comorbidities, infection source, SOFA scores, and arterial blood gas measurements were among the information that was retrospectively obtained from ICU medical records. A standardized data sheet was used to record the acid-base status, type of metabolic disruption, ICU stay, and in-hospital mortality.

Study Procedure: Medical records of eligible patients hospitalized to the intensive care unit during the study period were examined following ethical approval. Clinical and demographic information was documented, including SOFA ratings, comorbidities, and the source of infection. Patients were categorized into four acid-base groups based on their arterial blood gas (ABG) findings at the time of ICU admission: normal, metabolic acidosis, respiratory alkalosis, or combination diseases. A large or normal anion gap was used to further categorize metabolic acidosis. ICU outcomes were recorded, including length of stay and in-hospital mortality. In order to evaluate correlations with sepsis severity and outcomes, all data were recorded into a standardized sheet and patients were examined based on their acid-base balance.

Statistical Analysis: The statistical analysis was conducted using SPSS version 26.0. Microsoft Excel was used to originally enter the data. The information has been displayed as mean±SD or as the number of participants (n) with percentages (%).

For statistical analysis, the independent t-test was employed. A p-value of less than 0.05 was considered to be statistically significant.

Results

The average age of the study population was 56.4 ± 14.2 years. Of the cohort, 60.5% (n = 98) were male volunteers. The most frequent source of infection was the respiratory tract (38.3%, n = 62), which was followed by urinary tract infections (18.5%, n = 30) and stomach infections (26.5%, n = 43). The study participants' demographic profile is detailed in Table 1.

Table 1: Demographic Profile of Study Participants

Variable	Value
Age (in years)	56.4 ± 14.2
Male Participants	98 (60.5)
Female Participants	64 (39.5)
Source of infection, n (%)	
Respiratory	62 (38.3)
Abdominal	43 (26.5)
Urinary tract	30 (18.5)
Others (soft tissue/bloodstream)	27 (16.7)
Septic shock, n (%)	68 (42.0)
Mean SOFA score	7.8 ± 3.4

Metabolic acidosis was the most common abnormality, seen in 72 participants. Normal acid–base status was observed in 34 participants. Mixed metabolic acidosis with respiratory alkalosis was present in 34 participants, indicating combined disturbances. Respiratory alkalosis alone was seen in 18 participants. Metabolic alkalosis was rare, occurring in only 4 participants. Figure 1 shows acid base status among study participants.

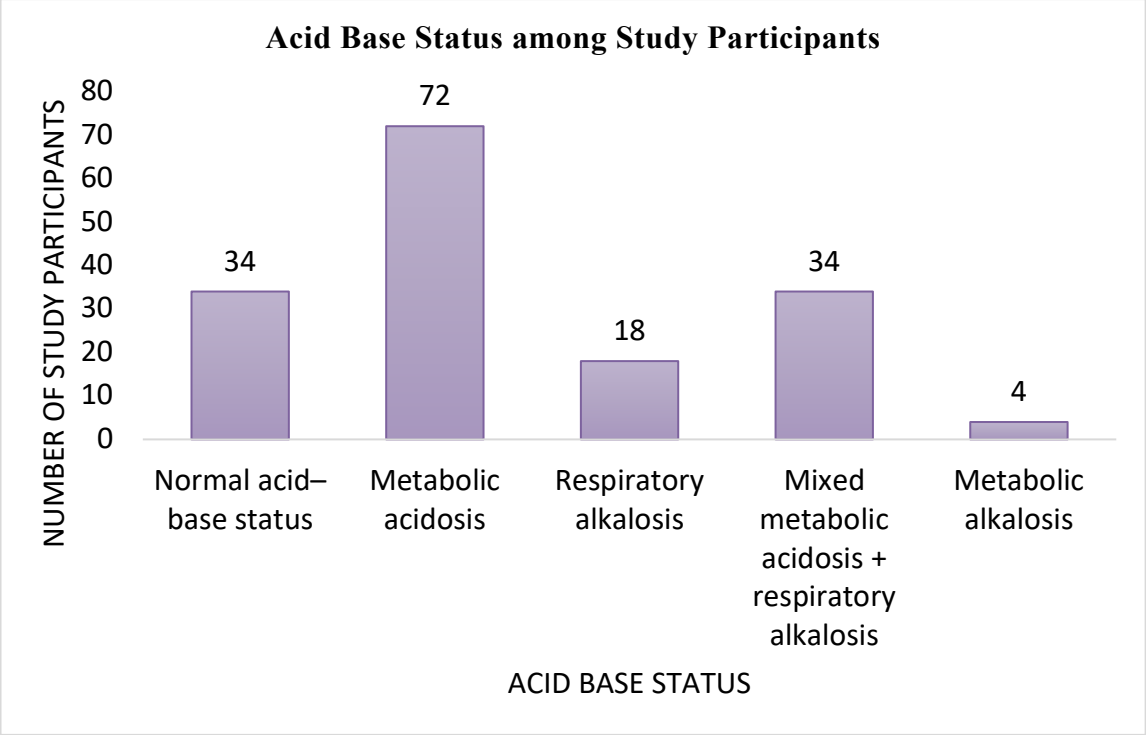

Figure 1: Acid Base Status among Study Participants

The largest subgroup consisted of patients with metabolic acidosis, who also had the highest mean SOFA score (9.6 ± 3.2) and the highest percentage of septic shock (58.8%). In a similar vein, patients with a combined acid-base problem had a significantly higher mean SOFA score (8.9 ± 2.8) and a high rate of septic shock (52.9%). On the other hand, patients with normal acid-base status had a lower mean SOFA score (5.4 ± 2.1) and a significantly reduced incidence of septic shock (17.6%). Septic shock prevalence and SOFA ratings showed statistically significant differences between acid-base categories ($p < 0.001$). The relationship between acid-base imbalances and the severity of sepsis is seen in Table 2.

Table 2: Association Between Acid–Base Disturbances and Sepsis Severity

Acid–Base Status	Septic Shock Present n (%)	Mean SOFA Score (± SD)
Normal acid–base	6 (17.6)	5.4 ± 2.1
Metabolic acidosis	40 (58.8)	9.6 ± 3.2
Mixed disorder	18 (52.9)	8.9 ± 2.8
Respiratory alkalosis	4 (22.2)	6.1 ± 2.4
p-value	**< 0.001**	**< 0.001**

Among patients with metabolic acidosis, high anion gap metabolic acidosis was the predominant type (n = 42). Normal anion gap metabolic acidosis was observed in fewer patients (n = 30). Figure 2 shows type of metabolic acidosis among study participants.

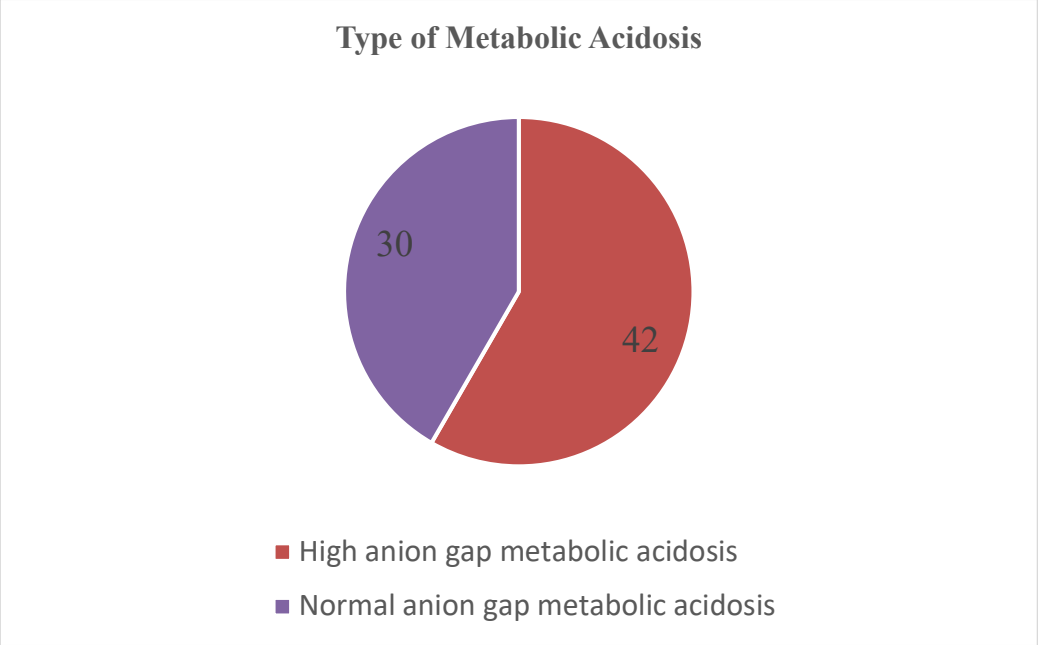

Figure 2: Type of Metabolic Acidosis among Study Participants

The longest ICU stay (8.9 ± 3.6 days), largest septic shock prevalence, and worst death (45.8%) were all linked to metabolic acidosis. High mortality (41.2%), frequent septic shock, and extended ICU stay (8.3 ± 3.1 days) were also observed in mixed acid-base disorders. Individuals with normal acid-base status had shorter ICU stays (5.1 ± 2.4 days), lower mortality (11.8%), and fewer septic shock. Clinical results by acid-base status are shown in Table 3.

Table 3: Clinical Outcomes According to Acid–Base Status

Acid–Base Status	Mortality n (%)	ICU Stay (in days)
Normal acid–base	4 (11.8)	5.1 ± 2.4
Metabolic acidosis	33 (45.8)	8.9 ± 3.6
Mixed disorder	14 (41.2)	8.3 ± 3.1
Respiratory alkalosis	2 (11.1)	5.8 ± 2.6
p-value	**< 0.001**	**< 0.001**

Discussion

Acid-base disturbances were shown to be prevalent in ICU patients with sepsis in this study. Metabolic acidosis was the most common abnormality, followed by pulmonary alkalosis and mixed acid-base disorders. The highest rates of septic shock, higher SOFA scores, longer ICU stays, and higher mortality were found in patients with metabolic acidosis. While patients with normal acid-base status had substantially lower severity and better outcomes, mixed acid-base disturbances were also linked to significant severity and bad outcomes. These results demonstrate that acid-base abnormalities may be a predictive factor and an indicator of the severity of sepsis.

According to earlier research, lactic acidosis brought on by tissue hypoperfusion and organ failure is frequently seen in critically sick patients [8, 9], which is consistent with the high frequency of metabolic acidosis in sepsis patients. The most common kind in this group was high anion gap metabolic acidosis, which was caused by sepsis-induced metabolic abnormalities, renal failure, and underlying lactic acid buildup [8]. Patients with mixed illnesses frequently exhibited both respiratory alkalosis and metabolic acidosis, which can be brought on by compensatory hyperventilation in reaction to either sepsis-related respiratory dysfunction or metabolic acidosis [10, 11].

Higher SOFA scores are strongly correlated with acid-base abnormalities, which highlights their significance as a proxy for organ dysfunction. Our findings are corroborated by prior research showing that metabolic acidosis in sepsis is associated with higher mortality and longer ICU stays [12]. According to Kiessling SG et al., sepsis, diabetic ketoacidosis, and renal failure are the most frequent causes of metabolic acidosis in the intensive care unit [13].

Metabolic acidosis with respiratory alkalosis is the most prevalent mixed acid-base illness in ICU sepsis patients, according to Thomas DD et al. [14], which is consistent with the current study. Additionally, metabolic acidosis and pulmonary alkalosis were

linked to critically sick patients, according to a study by Grogan H. et al. [15]. According to Fencl V et al., septic shock and renal failure with sepsis were the common causes of the aforementioned mixed acid base illness [16].

According to a related study by Rajendran B et al., metabolic acidosis is the most prevalent simple type of acid base disorder, and mixed acid base disorders, which include metabolic acidosis with respiratory alkalosis in infectious diseases, are the most frequent disturbances in the intensive care setup [17].

Conclusion

Acid-base imbalances were found to be closely linked to the severity and results of sepsis in this investigation. Compared to patients with normal acid-base status, those with metabolic acidosis and mixed acid-base disorders had far greater rates of septic shock, higher SOFA scores, longer ICU stays, and higher mortality. In order to enhance clinical outcomes, early detection and monitoring of acid-base imbalances in sepsis patients may be a crucial prognostic sign and direct prompt treatment actions.

Limitations

It might not be possible to generalize the results of this study to a larger population because it was carried out in a single urban tertiary care facility. Furthermore, the study's sample size was insufficient for extrapolating results and drawing inferences.

Recommendations

Since patients with metabolic acidosis or mixed acid-base abnormalities are more likely to experience septic shock, organ failure, and death, early evaluation and monitoring of acid-base status should be a crucial component of sepsis care. Standard sepsis therapy combined with prompt adjustment of these imbalances may lead to better results. To confirm these results and investigate the function of acid-base monitoring in ICU prognostic scoring and early risk classification, more multicentric research is advised.

List of Abbreviations

ABG- Arterial Blood Gas

ICU- Intensive Care Unit

SOFA- Sequential Organ Failure Assessment

MAP- Mean Arterial Pressure

HR- Heart Rate

BP- Blood Pressure

GCS- Glasgow Coma Scale

References

1. Evans L, Rhodes A, Alhazzani W, Antonelli M, Coopersmith CM, French C, Machado FR, Mcintyre L, Ostermann M, Prescott HC, Schorr C. Surviving sepsis campaign: international guidelines for management of sepsis and septic shock 2021. Critical care medicine. 2021 Nov 1;49(11):e1063-143.
2. Angus DC, Van der Poll T. Severe sepsis and septic shock. New England journal of medicine. 2013 Aug 29;369(9):840-51.
3. Singer M, Deutschman CS, Seymour CW, Shankar-Hari M, Annane D, Bauer M, Bellomo R, Bernard GR, Chiche JD, Coopersmith CM, Hotchkiss RS. The third international consensus definitions for sepsis and septic shock (Sepsis-3). Jama. 2016 Feb 23;315(8):801-10.
4. Vincent JL. The clinical challenge of sepsis identification and monitoring. PLoS medicine. 2016 May 17;13(5):e1002022.
5. Rudd KE, Johnson SC, Agesa KM, Shackelford KA, Tsoi D, Kievlan DR, Colombara DV, Ikuta KS, Kissoon N, Finfer S, Fleischmann-Struzek C. Global, regional, and national sepsis incidence and mortality, 1990–2017: analysis for the Global Burden of Disease Study. The Lancet. 2020 Jan 18;395(10219):200-11.
6. Maharaj R, McGuire A, Street A. Association of annual intensive care unit sepsis caseload with hospital mortality from sepsis in the United Kingdom, 2010-2016. JAMA network open. 2021 Jun 1;4(6):e2115305-.
7. Markwart R, Saito H, Harder T, Tomczyk S, Cassini A, Fleischmann-Struzek C, Reichert F, Eckmanns T, Allegranzi B. Epidemiology and burden of sepsis acquired in hospitals and intensive care units: a systematic review and meta-analysis. Intensive care medicine. 2020 Aug;46(8):1536-51.
8. Kellum JA. Disorders of acid-base balance. Critical care medicine. 2007 Nov 1;35(11):2630-6.
9. Al-Jaghbeer M, Kellum JA. Acid–base disturbances in intensive care patients: etiology, pathophysiology and treatment. Nephrology Dialysis Transplantation. 2015 Jul 1;30(7):1104-11.
10. Niwa T. Mass spectrometry in diabetes mellitus. Clinica chimica acta; international journal of clinical chemistry. 1995;241:191-220.
11. Mohan A, Sharma SK. Acid base disorders. In: Munjal YP, eds. API Textbook of Medicine. 9th ed. Mumbai; Assoc-Physicians: Ind; 2012: 239-245.
12. Evans L, Rhodes A, Alhazzani W, Antonelli M, Coopersmith CM, French C, Machado FR, Mcintyre L, Ostermann M, Prescott HC, Schorr C. Surviving sepsis campaign: international guidelines for management of sepsis and septic

shock 2021. Critical care medicine. 2021 Nov 1;49(11):e1063-143.
13. Kiessling SG, Goebel J, Somers MJ, editors. Pediatric Nephrology in the ICU. Springer Science & Business Media; 2008 Nov 16.
14. DuBose TD. Acidosis and alkalosis. Harrison's principles of internal medicine. 2005;16(1):263.
15. Grogan H, Hopkins PM. Heat stroke: implications for critical care and anaesthesia. British journal of anaesthesia. 2002 May 1;88(5):700-7.
16. Fencl V, Jabor A, Kazda A, Figge J. Diagnosis of metabolic acid–base disturbances in critically ill patients. American journal of respiratory and critical care medicine. 2000 Dec 1;162(6):2246-51.
17. Rajendran B, Mallampati SR. Acid based disorders in intensive care unit: a hospital-based study.