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(2); 467-471

Original Research Article

Acid–Base Disorders in Critically Ill Patients Admitted to a Tertiary Care Intensive Care Unit: An Observational Study

Saraswati Prajapati[1], Hema Deep Bhojani[2], Harsh Patel[3], Priyanka Patel[4]

[1]Asisstant Professor, Department of General Medicine, Dr. M. K. Shah Medical College & Research Center & Smt SMS Multispecialty Hospital, Ahmedabad, Gujarat, India

[2]Associate Professor, Department of General Medicine, Dr. M. K. Shah Medical College & Research Center & Smt SMS Multispecialty Hospital, Ahmedabad, Gujarat, India

[3,4]Senior Resident, Department of General Medicine, Dr. M. K. Shah Medical College & Research Center & Smt SMS Multispecialty Hospital, Ahmedabad, Gujarat, India

Received: 01-11-2025 / Revised: 15-12-2025 / Accepted: 21-01-2026

Corresponding author: Dr. Harsh Patel

Conflict of interest: Nil

Abstract

Background: Disturbances in acid–base balance are frequently encountered in critically ill patients and often reflect the severity of the underlying illness. These abnormalities have been consistently associated with increased morbidity and mortality in intensive care units (ICUs).

Objectives: To evaluate the pattern of acid–base disorders in ICU patients and to determine their association with mortality.

Methods: This prospective observational study was conducted over a 12-month period in the medical ICU of a tertiary care teaching hospital in western India. One hundred adult patients admitted for more than 12 hours were included. Acid–base disorders were identified using arterial blood gas (ABG) analysis following a structured five-step interpretative approach. Acid–base and biochemical parameters were compared between survivors and non-survivors.

Results: The mean age of the study population was 52.6 ± 13.36 years, with a male predominance (63%). Mixed acid–base disorders were more frequent than isolated abnormalities (61% vs 39%). Metabolic acidosis (18%) was the most common isolated disorder, while metabolic alkalosis combined with respiratory alkalosis (23%) was the most frequent mixed disorder. ARDS (28%) and sepsis (18%) were the leading primary diagnoses. Overall mortality was 35%. Non-survivors had significantly lower pH, bicarbonate, sodium, and oxygen saturation, along with higher $PaCO_2$, anion gap, and serum creatinine ($p < 0.05$).

Conclusions: Acid–base disorders are highly prevalent among critically ill patients, with mixed abnormalities predominating. Significant derangements in acid–base parameters are associated with increased mortality, emphasizing the importance of early recognition and timely correction.

Keywords: Acid–base disorders; arterial blood gas; intensive care unit; mortality.

DOI: 10.25258/ijcpr.18.2.73

Introduction

Maintenance of acid–base homeostasis is essential for normal cellular metabolism, enzymatic activity, and cardiovascular stability [1]. In critically ill patients, this balance is frequently disrupted due to sepsis, respiratory failure, renal dysfunction, metabolic derangements, and iatrogenic factors such as intravenous fluid therapy and mechanical ventilation [2,3,8]. These disturbances often coexist, resulting in complex mixed acid–base disorders in ICU settings.

Previous studies have demonstrated that a substantial proportion of ICU patients develop metabolic acidosis or mixed acid–base abnormalities, both of which are associated with increased morbidity and mortality [1,4,7]. Acute deviations in blood pH can impair myocardial contractility, reduce oxygen delivery, alter vascular tone, and precipitate multiorgan dysfunction [9–11]. Arterial blood gas analysis remains the cornerstone for evaluating acid–base status, ventilation, and oxygenation in critically ill patients [3–5]. A structured approach to ABG interpretation facilitates early identification of mixed and triple acid–base disorders, which are particularly common in ICU populations [6,12].

However, data describing the spectrum and prognostic relevance of acid–base disorders from Indian ICUs are limited. The present study was therefore undertaken to characterize acid–base abnormalities in critically ill patients and examine their relationship with clinical outcomes.

Materials and Methods

Study Design and Setting: This prospective observational study was conducted in the medical ICU of a tertiary care urban teaching hospital in Ahmedabad, India.

Study Duration: December 2021 to December 2022.

Study Population: A total of 100 adult patients admitted to the medical ICU were enrolled.

Inclusion Criteria

- Age ≥ 18 years
- ICU stay of at least 12 hours

Exclusion Criteria

- Surgical ICU admissions
- Obstetric and gynecological patients
- Incomplete clinical or laboratory records

Ethical Considerations: Approval was obtained from the Institutional Ethics Committee. Written informed consent was secured from patients or their legally authorized representatives in accordance with established ethical guidelines [14].

Acid–Base Analysis: Arterial blood samples were obtained under aseptic conditions. Acid–base disorders were evaluated using a standardized five-step approach based on classical and contemporary acid–base physiology [3–6,12]:

1. Validation of ABG values
2. Identification of the primary acid–base disorder using pH
3. Assessment of expected compensatory responses
4. Calculation of the anion gap
5. Detection of mixed or triple acid–base disorders

Interpretation of the anion gap was performed with consideration of its known limitations in critically ill patients, particularly in the presence of hypoalbuminemia [15,16].

Statistical Analysis: Statistical analysis was performed using IBM SPSS version 22.0. Continuous variables were expressed as mean ± standard deviation and compared using Student's t-test. Categorical variables were expressed as proportions and analyzed using the Chi-square or Fisher's exact test. A p-value < 0.05 was considered statistically significant [17].

Results

Demographic Profile: The mean age of the study population was 52.6 ± 13.36 years. Male patients accounted for 63% of the cohort.

Table 1: Demographic characteristics of ICU patients (N = 100)

Variable	Value
Mean age (years)	52.6 ± 13.36
Male	63 (63%)
Female	37 (37%)
Male : Female ratio	1.7 : 1

Comorbidities: Hypertension (66%) and diabetes mellitus (58%) were the most frequently observed comorbid conditions, followed by chronic obstructive pulmonary disease, cerebrovascular disease, chronic liver disease, and chronic kidney disease.

Table 2: Distribution of comorbidities

Comorbidity	Number (%)
Hypertension	66 (66%)
Diabetes mellitus	58 (58%)
COPD	25 (25%)
Cerebrovascular disease	19 (19%)
Chronic liver disease	17 (17%)
Chronic kidney disease	16 (16%)

Primary Diagnosis: ARDS was the most common indication for ICU admission, followed by sepsis and acute exacerbation of COPD.

Table 3: Primary diagnosis at ICU admission

Diagnosis	Number (%)
ARDS	28 (28%)
Sepsis	18 (18%)
Acute exacerbation of COPD	14 (14%)
Diabetic ketoacidosis	11 (11%)
Decompensated CLD	10 (10%)
AKI on CKD	8 (8%)
Miscellaneous	11 (11%)

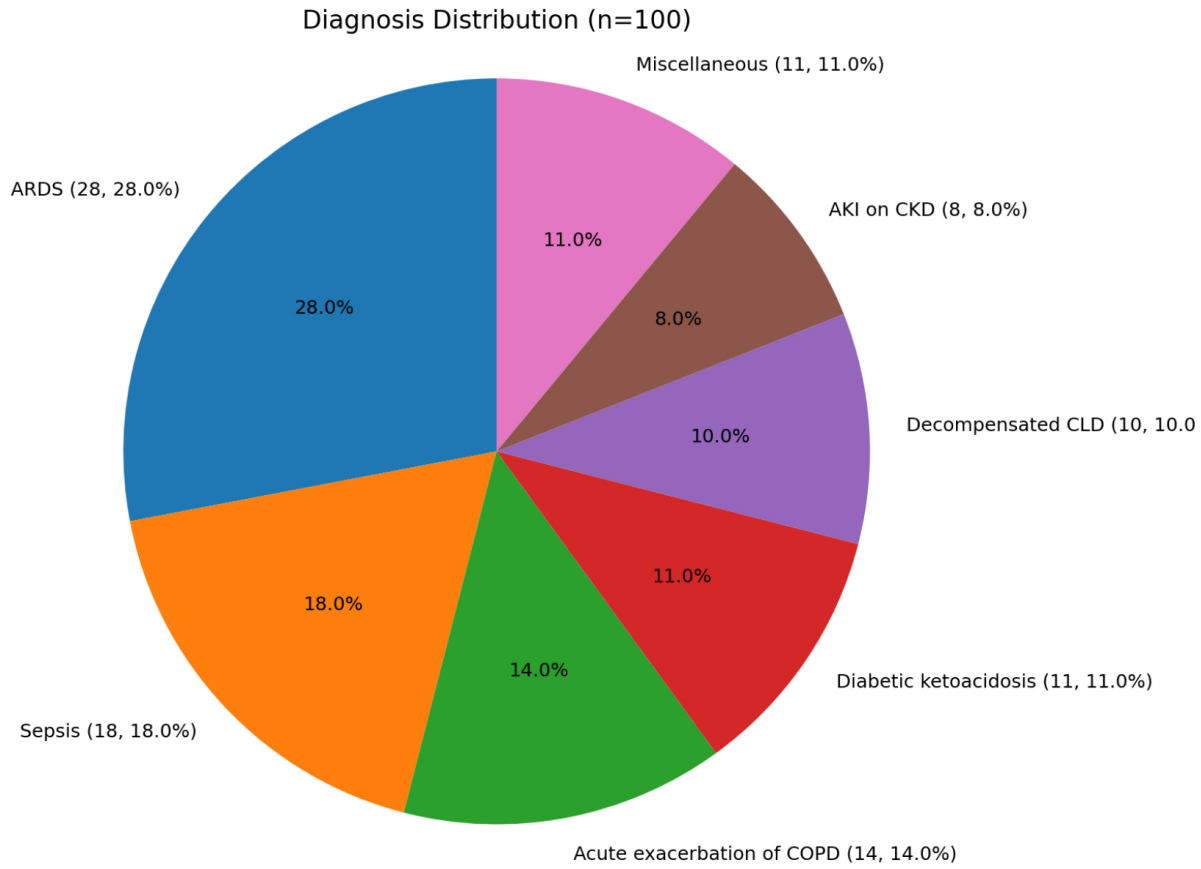

Figure 1: Primary diagnosis

Pattern of Acid–Base Disorders: Mixed acid–base disorders were observed more frequently than isolated abnormalities (61% vs 39%). Among isolated disorders, metabolic acidosis predominated. The most frequent mixed pattern was metabolic alkalosis combined with respiratory alkalosis.

Table 4: Pattern of acid–base disorders

Acid–base disorder	Number (%)
Simple disorders	
Metabolic acidosis	18 (18%)
Metabolic alkalosis	13 (13%)
Respiratory alkalosis	4 (4%)
Respiratory acidosis	4 (4%)
Mixed disorders	
Metabolic alkalosis + respiratory alkalosis	23 (23%)
Metabolic acidosis + respiratory acidosis	18 (18%)
Metabolic alkalosis + respiratory acidosis	9 (9%)
Metabolic acidosis + respiratory alkalosis	7 (7%)
Triple acid–base disorders	4 (4%)

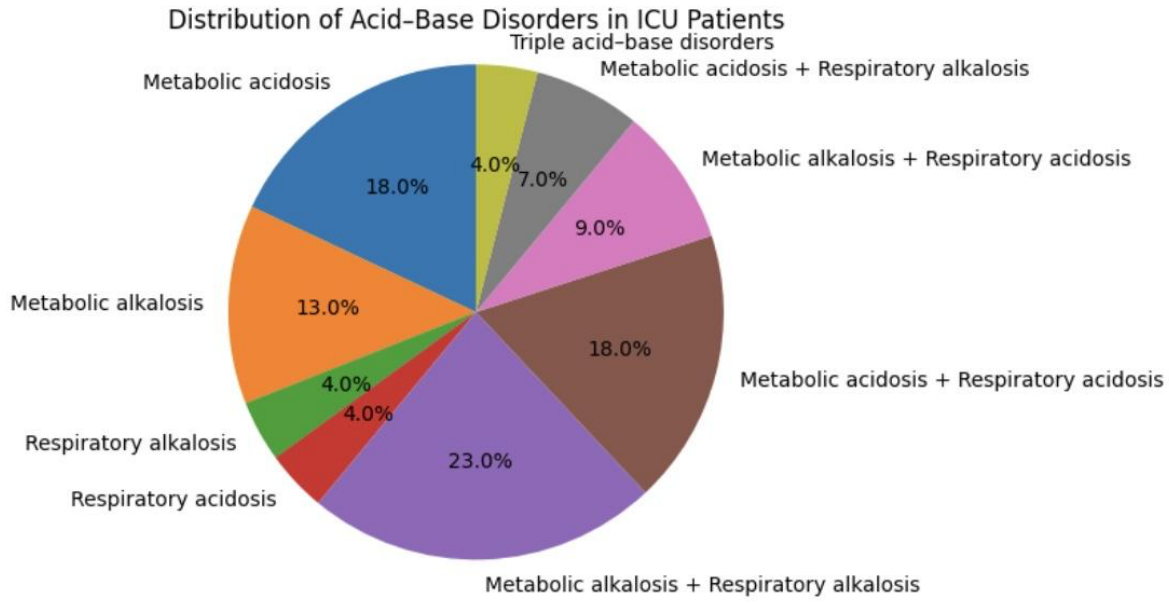

Figure 2: Pattern of Acid base disorder

Clinical Outcome: Overall mortality in the study population was 35%.

Table 5: Comparison of acid–base parameters in survivors and non-survivors

Parameter	Survivors	Non-survivors	p-value
pH	7.39 ± 0.12	7.20 ± 0.70	0.031
$PaCO_2$ (mmHg)	36.84 ± 16.36	54.73 ± 35.80	<0.0001
HCO_3^- (mEq/L)	25.16 ± 7.03	21.28 ± 8.90	0.019
Anion gap (mEq/L)	11.03 ± 4.49	15.74 ± 3.45	<0.0001
SaO_2 (%)	95.10 ± 2.40	93.08 ± 1.70	<0.0001
Serum creatinine (mg/dL)	1.11 ± 0.15	1.88 ± 0.47	<0.0001
Sodium (mEq/L)	135.93 ± 5.17	132.02 ± 5.40	<0.0001

Discussion

The present study demonstrates a high prevalence of acid–base disturbances among critically ill patients, with mixed acid–base disorders occurring more frequently than isolated abnormalities. This finding mirrors observations from previous ICU-based studies and reflects the complex, multifactorial pathophysiology of critical illness [1,7,18–20]. Metabolic acidosis was the most common isolated disorder, likely attributable to sepsis, renal dysfunction, lactic acidosis, and diabetic ketoacidosis [9,23–25]. The predominance of mixed acid–base disorders among patients with ARDs may be explained by the combined effects of hypoxia, systemic inflammation, dehydration, and multiorgan involvement. Non-survivors exhibited more severe derangements in pH, bicarbonate, $PaCO_2$, anion gap, renal function, and electrolyte levels. These abnormalities have consistently been associated with adverse outcomes in critically ill populations, highlighting their prognostic significance [1,2,26].

Conclusions

Acid–base disturbances are extremely common in critically ill patients admitted to ICUs, with mixed disorders predominating. Significant abnormalities in pH, bicarbonate, $PaCO_2$, anion gap, and renal parameters are associated with increased mortality. Routine ABG analysis using a structured interpretative approach, along with early correction of identified abnormalities, may contribute to improved outcomes in critically ill patients [1,2].

References

1. Kellum JA. Disorders of acid–base balance. Crit Care Med. 2007; 35:2630-2636.
2. Al-Jaghbeer M, Kellum JA. Acid–base disturbances in intensive care patients. Nephrol Dial Transplant. 2014; 30:1104-1111.
3. Seifter JL. Acid–base disorders. N Engl J Med. 2014; 371:1821-1831.
4. Seifter JL. Acid–base disorders. In: Cecil Textbook of Medicine. 25th ed. Elsevier; 2015:762-774.
5. Mohan A, Sharma SK. Acid–base disorders. In: API Textbook of Medicine. 9th ed. Mumbai; 2012:239-245.
6. Stewart PA. Modern quantitative acid–base chemistry. Can J Physiol Pharmacol. 1983; 61:1444-1461.
7. Gunnerson KJ, Saul M, He S, et al. Lactate versus non-lactate metabolic acidosis. Crit Care Med. 2006;34: R22.
8. Story DA. Intravenous fluid administration and controversies in acid–base balance. Crit Care Resusc. 1999; 1:151-156.
9. Mizock BA, Falk JL. Lactic acidosis in critical illness. Crit Care Med. 1992; 20:80-93.
10. Kette F, Weil MH, Gazmuri RJ. Buffer solutions and cardiac resuscitation. JAMA. 1991; 266:2121-2126.
11. Hindman BJ. Sodium bicarbonate in lactic acidosis. Anesthesiology. 1990; 72:1064-1076.
12. Corey HE. Stewart and beyond. Kidney Int. 2003; 64:777-787.
13. Figge J, Mydosh T, Fencl V. Serum proteins and acid–base equilibria. J Lab Clin Med. 1992;120:713-719.
14. World Medical Association. Declaration of Helsinki. JAMA. 2013; 310:2191-2194.
15. Kraut JA, Nagami GT. The anion gap in acid–base disorders. Clin J Am Soc Nephrol. 2013; 8:2018-2024.
16. Salem MM, Mujais SK. Gaps in the anion gap. Arch Intern Med. 1992; 152:1625-1629.
17. Altman DG. Practical Statistics for Medical Research. Chapman & Hall; 1991.
18. Boniatti MM, et al. Acid–base disorders in ICU patients. Intensive Care Med. 2011; 37:106-113.
19. Köse A, et al. Acid–base disorders and outcomes. Eurasian J Emerg Med. 2014; 13:1-6.
20. Musleh BA, et al. Acid–base disturbances in ICU. J Clin Diagn Res. 2016;10:OC01-OC04.
21. Modi R, et al. Acid–base disorders in ICU patients. J Assoc Physicians India. 2018; 66:44-48.
22. Weil MH, Afifi AA. Lactate as indicator of shock severity. Circulation. 1970; 41:989-1001.
23. Mikkelsen ME, et al. Lactate and mortality in sepsis. Crit Care Med. 2009; 37:1670-1677.
24. Alberti KGMM. Diabetic emergencies. BMJ. 1989; 45:242-263.
25. Levy B. Lactate and shock state. Curr Opin Crit Care. 2006; 12:315-321.
26. Yunos NM, et al. Chloride-rich fluids and acut e kidney injury. JAMA. 2012; 308:1566-1572.