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ACID–BASE DISORDERS, COMORBIDITIES, AND CLINICAL OUTCOMES IN A RURAL TERTIARY CARE HOSPITAL: A PROSPECTIVE OBSERVATIONAL STUDY

General Medicine

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ABSTRACT

Acid–base disorders are among the most frequent and clinically consequential biochemical abnormalities encountered in hospitalized patients. This prospective observational study enrolled 100 adults admitted with arterial-blood-gas–confirmed acid–base disturbances at the Department of General Medicine, Kamineni Institute of Medical Sciences, Narketpally, Telangana, from January 2024 to December 2025. The cohort was predominantly male (63%) and elderly (32% aged 68–77 years). Hypertension (51%) and diabetes mellitus (42%) were the most prevalent comorbidities. Metabolic acidosis was the most common disorder (48%), followed by mixed respiratory and metabolic acidosis (22%). Overall in-hospital mortality was 28%. Requirement of mechanical ventilation (Adjusted OR 32.4; 95% CI 8.9–118.2; p=0.001) and tachycardia ≥100 bpm at admission (Adjusted OR 2.88; 95% CI 1.02–8.16; p=0.04) were identified as independent predictors of mortality on multivariate logistic regression. Individual biochemical parameters (pH, HCO_3^-, PCO_2) demonstrated poor discriminatory ability for mortality prediction (AUC <0.60). Early recognition of ventilatory failure and haemodynamic instability is essential to improve outcomes.

KEYWORDS

Acid–base Disorders; Metabolic Acidosis; Arterial Blood Gas; Mechanical Ventilation; Mortality Predictors; Rural India

INTRODUCTION

Acid–base disorders represent one of the most frequently encountered biochemical abnormalities in hospitalized patients, particularly in tertiary care centres.1,2 These disorders arise from disturbances in hydrogen-ion concentration resulting from respiratory or metabolic dysfunction and include metabolic acidosis, metabolic alkalosis, respiratory acidosis, respiratory alkalosis, and mixed acid–base disorders. Acid–base imbalance reflects underlying systemic illness and is often associated with conditions such as sepsis, renal failure, diabetic ketoacidosis, chronic lung disease, cardiovascular disorders, and drug toxicity.[3]

Even mild derangements in pH can significantly impair cellular metabolism, cardiovascular performance, oxygen delivery, and enzymatic activity, leading to increased morbidity and mortality.1 Studies indicate that 55–75% of ICU admissions develop at least one acid–base abnormality during hospitalisation.3 Metabolic acidosis is the most common disorder, occurring in 30–50% of critically ill patients; in-hospital mortality in severe acidaemia (pH <7.20) exceeds 50%.4,6 Most existing studies are from Western populations or ICU-based settings, limiting applicability to the Indian healthcare context.5 The present study was conducted to evaluate the clinical profile, etiological spectrum, biochemical characteristics, and outcome predictors of acid–base disorders in a rural tertiary care setting in Telangana.

METHODS

A prospective observational study was conducted at the Department of General Medicine, Kamineni Institute of Medical Sciences (KIMS), Narketpally, Telangana, from January 2024 to December 2025. One hundred consecutive adults (≥18 years) admitted with ABG-confirmed acid–base disturbances were enrolled after informed consent; patients below 18 years or unwilling to consent were excluded. Sample size was estimated by Cochran's formula assuming 50% prevalence (minimum n=96; enrolled n=100).

All patients underwent detailed clinical history, vital parameter recording, and laboratory assessment including ABG analysis (pH, $PaCO_2$, HCO_3^-), serum electrolytes, renal function tests, serum lactate, and blood glucose. Acid–base disorders were classified using standard physiological and anion-gap–based criteria as described by Berend et al.7 Comorbidities were recorded and in-hospital outcomes classified as improvement, unchanged, worsening, or death. Statistical analysis used SPSS v24.0: chi-square and Fisher's exact tests for associations; univariate and multivariate logistic regression for independent mortality predictors; and ROC curve analysis for biochemical predictive accuracy. Ethics Committee approval was obtained (IEC, KIMS).

RESULTS

Demographic and Clinical Profile

The cohort comprised 63 males (63%) and 37 females (37%). The majority (32%) belonged to the 68–77-year age group (Figure 1A), with 24% in the 58–67 group, reflecting elderly predominance. Shortness of breath (52%), fever (40%), and weakness of limbs (25%) were the most common presenting complaints. Hypertension was the most prevalent comorbidity (51%), followed by diabetes mellitus (42%), CKD (19%), CVA (10%), CAD (7%), and tuberculosis (7%) (Figure 2). Fifteen per cent had no identifiable comorbidity.

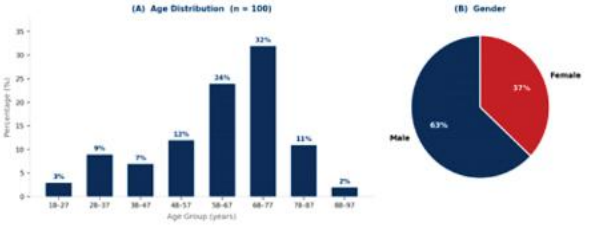

Figure 1: (A) Age distribution of the study cohort (n=100). (B) Gender distribution: male predominance (63%).

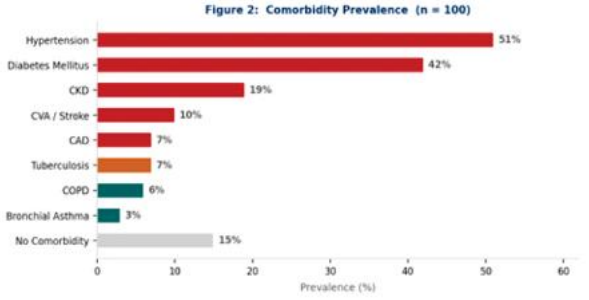

Figure 2: Comorbidity prevalence (n=100). Hypertension (51%) and diabetes mellitus (42%) were most common.

Acid–Base Disorder Type and Outcome

Metabolic acidosis was the most common disorder (48%), with improvement in 70.8% and mortality in 20.8%. Mixed respiratory and metabolic acidosis (22%) carried the highest mortality (54.5%). Mixed respiratory alkalosis with metabolic acidosis was seen in 19%, with 73.7% improving. Overall mortality was 28%; improvement was achieved in 63% of patients. The distribution and outcome by disorder type are shown in Figure 3 and Table 1.

Figure 3: (A) Distribution of acid–base disorder types (n=100). (B)

Outcome (improved vs death %) by disorder type. Mixed respiratory + metabolic acidosis had the highest mortality (54.5%).

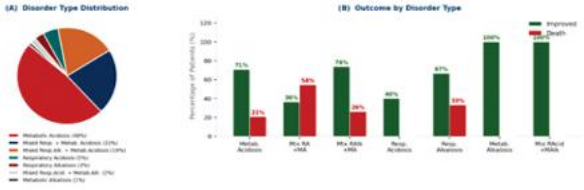

TABLE – 1 ACID–BASE DISORDER TYPE AND IN-HOSPITAL OUTCOME

Disorder Type	n	Improved n(%)	Same n(%)	Worsened n(%)	Death n(%)	Mortality %
Metabolic acidosis	48	34 (70.8)	2 (4.2)	2 (4.2)	10 (20.8)	20.8%
Mixed resp. + metab. acidosis	22	8 (36.4)	1 (4.5)	1 (4.5)	12 (54.5)	**54.5% ★**
Mixed resp.alk. + metab. acidosis	19	14 (73.7)	0 (0)	0 (0)	5 (26.3)	26.3%
Respiratory acidosis	5	2 (40.0)	2 (40.0)	1 (20.0)	0 (0)	0%
Respiratory alkalosis	3	2 (66.7)	0 (0)	0 (0)	1 (33.3)	33.3%
Metabolic alkalosis	1	1 (100)	0 (0)	0 (0)	0 (0)	0%
Mixed resp.acid. + metab.alk.	2	2 (100)	0 (0)	0 (0)	0 (0)	0%
TOTAL	**100**	**63 (63)**	**5 (5)**	**4 (4)**	**28 (28)**	**28%**

★ Highest mortality category. Fisher's Exact test and χ^2 test used for categorical comparisons.

Interventions and Outcome

Medical management alone achieved improvement in 31/34 patients (91.2%); no deaths occurred in this group — the remaining 8.8% comprised patients with unchanged (2.9%) or worsened (5.9%) status. NIV was similarly effective (92.3% improvement; 7.7% mortality, n=1). In contrast, mechanical ventilation was required in 42 patients and carried 62% mortality. Combined MV and dialysis was associated with 62.5% mortality (Figure 4).

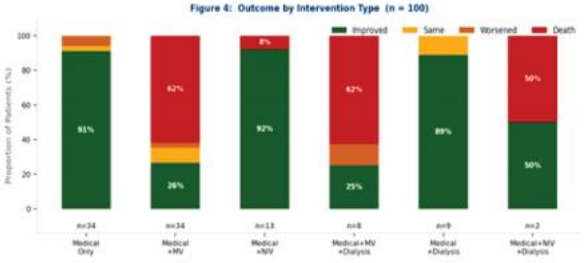

Figure 4: Stacked outcome proportions by intervention type (n=100). Medical-only group: 0% mortality (91.2% improved, 8.8% unchanged/worsened). NIV group: 7.7% mortality (1/13). MV groups: >60% mortality.

Predictors of Mortality

Mechanical ventilation (AOR 32.4; p=0.001) and tachycardia ≥100 bpm (AOR 2.88; p=0.04) were the only independent predictors of mortality on multivariate analysis. Age, comorbidities, severe acidaemia, and dialysis requirement were not significant after adjustment (Table 2; Figure 5). Individual biochemical parameters demonstrated poor discriminatory ability (all AUC <0.60; Table 3).

TABLE – 2 UNIVARIATE AND MULTIVARIATE PREDICTORS OF IN-HOSPITAL MORTALITY

Variable	Category	Univariate OR (95% CI)	Multivariate AOR (95% CI)	p value
Mechanical ventilation	Required	45.5 (14.1–146.3)	**32.4 (8.9–118.2)**	**0.001***
Heart rate	≥100 bpm	3.97 (1.26–12.48)	**2.88 (1.02–8.16)**	**0.04***
Age	>60 years	1.08 (0.45–2.55)	0.96 (0.35–2.61)	0.94 NS
Comorbidities	Present	1.46 (0.30–2.90)	1.21 (0.39–3.72)	0.73 NS
Severe acidaemia	HCO_3^- <10	1.16 (0.45–3.02)	1.09 (0.36–3.32)	0.87 NS
Dialysis requirement	Yes	1.24 (0.44–3.46)	1.18 (0.37–3.69)	0.77 NS

* p<0.05. NS = not significant. AOR = Adjusted Odds Ratio from multivariate logistic regression.

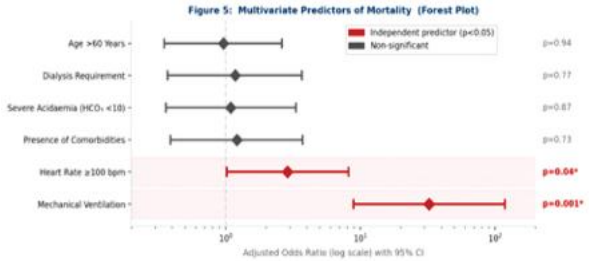

Figure 5: Forest plot of multivariate predictors of mortality. Mechanical ventilation (AOR 32.4, p=0.001) and tachycardia ≥100 bpm (AOR 2.88, p=0.04) are the only independent predictors (shaded rows).

TABLE – 3 ROC CURVE ANALYSIS: DISCRIMINATORY ABILITY FOR MORTALITY PREDICTION

Predictor Variable	AUC	Interpretation
pH	0.371	Poor
HCO_3^-	0.494	None
$PaCO_2$	0.585	Poor
Heart Rate	0.487	None
Respiratory Rate	0.539	Poor
Systolic Blood Pressure	0.437	Poor

AUC >0.70 = acceptable; 0.50–0.70 = poor; <0.50 = no discrimination. All individual parameters showed poor to no discriminatory ability.

DISCUSSION

Demographic Profile

The predominance of elderly patients—with the 68–77-year group comprising 32%—is consistent with published reports demonstrating that acid–base disturbances are more common in older individuals, reflecting higher chronic illness burden and reduced physiological reserve.8,9 Age-related decline in glomerular filtration, pulmonary mechanics, and homeostatic responses predisposes elderly patients to metabolic and respiratory derangements.1 Male predominance (63%) has been reported in comparable studies by Shreewastav et al.8 and Nokwanda Sithole et al.,10 and likely reflects greater exposure to chronic cardiopulmonary disease, tobacco, and alcohol in males.

Spectrum and Outcomes of Acid–Base Disorders

Metabolic acidosis (48%) was the most common disorder, consistent with its reported prevalence of 30–50% in critically ill patients.4 Renal failure (37%) and cardiovascular diseases (29%) were the principal non-infective etiologies, while respiratory infections (27%) led infective causes — a pattern consistent with Kausar et al.,11 who identified respiratory infections and renal dysfunction as dominant pathways for acid–base imbalance in septic critically ill patients. Mixed respiratory and metabolic acidosis (22%) carried the highest mortality (54.5%), reflecting simultaneous failure of both compensatory axes — a finding corroborated by Adrogüé and Madias,1 who established that combined derangements carry worse prognosis than isolated disorders. Canova et al.12 similarly identified mixed acidosis as the highest-mortality category in their CICU cohort (56.3%). Medical management alone and NIV achieved improvement in >90% of patients, underscoring the importance of early, non-escalating management.

Predictors of Mortality and Biochemical Discrimination

Mechanical ventilation emerged as the strongest independent predictor of mortality (AOR 32.4; p=0.001), consistent with Shreewastav et al.8 and Canova et al.12 Invasive ventilation is best understood as a surrogate for severe respiratory failure, hypoxaemia, or multi-organ dysfunction rather than a direct cause of death.9 Tachycardia ≥100 bpm (AOR 2.88; p=0.04) independently predicted mortality, reflecting sympathetic activation and cardiovascular instability induced by acidaemia.4 Jenifer Sinekalatha et al.13 similarly documented that acid–base and electrolyte disturbances were disproportionately prevalent among non-survivors. Biochemical parameters—pH, HCO_3^-, PCO_2—showed poor individual discriminatory ability (all AUC <0.60), indicating that overall clinical status and multi-organ involvement are superior prognostic markers compared to isolated ABG values.3

Limitations

Several limitations of the present study warrant acknowledgement. First, the single-centre design from a rural tertiary referral hospital limits external generalisability. Second, the sample size of n=100 reflects prospective enrolment to a pre-specified Cochran's formula target (minimum n=96). Monthly accrual of approximately four patients meeting strict ABG-confirmed consecutive enrolment criteria is consistent with the referral dynamics and defined catchment area of a rural teaching hospital. Third, an apparent discordance exists between the continuous ROC analysis for heart rate (AUC 0.487, no discrimination) and its significance in multivariate regression (AOR 2.88; p=0.04 when dichotomised at ≥100 bpm). This is not mathematically contradictory: the ROC AUC measures a continuous variable's global ranking ability, which is sensitive to non-monotonic distributions, while logistic regression tests a clinically meaningful binary threshold. The categorical cut-off of ≥100 bpm (physiological tachycardia) can yield a significant group-level difference even when the continuous AUC approaches 0.5, a recognised limitation of using continuous ROC analysis to evaluate dichotomised thresholds. Fourth, long-term post-discharge outcomes were not assessed.

CONCLUSION

Acid–base disturbances remain a significant clinical problem in tertiary care hospitals, predominantly affecting elderly males with underlying cardiometabolic comorbidities. Metabolic acidosis was the most common disorder; mixed respiratory and metabolic acidosis carried the highest mortality (54.5%). Overall in-hospital mortality was 28%. Mechanical ventilation (AOR 32.4; p=0.001) and tachycardia ≥100 bpm at admission (AOR 2.88; p=0.04) were the only independent predictors of mortality; individual biochemical parameters demonstrated poor discriminatory accuracy. Early identification of respiratory failure and haemodynamic instability, prompt institution of non-invasive ventilatory support, and systematic ABG monitoring are essential to improve outcomes. Strengthening critical care infrastructure at rural tertiary centres in Telangana remains a priority.

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