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Original Research Paper

General Medicine

A RETROSPECTIVE COHORT STUDY ON ABG AS A PROGNOSTIC TOOL IN ARDS

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ABSTRACT This study explores the prognostic value of arterial blood gas (ABG) analysis in patients diagnosed with Acute Respiratory Distress Syndrome (ARDS). It evaluates how ABG parameters—such as pH, PaO2, PaCO2, HCO3, and lactate—correlate with disease severity and outcomes, including ICU stay duration and mortality rates. The findings suggest that ABG serves as a valuable tool in stratifying risk and predicting prognosis in ARDS patients.This study explores the prognostic value of arterial blood gas (ABG) analysis in patients diagnosed with Acute Respiratory Distress Syndrome (ARDS). In a retrospective cohort of 100 ICU patients, key ABG parameters—pH < 7.25, PaO_2 < 60 mmHg, and lactate > 2.5 mmol/L—were significantly associated with higher mortality rates ($p < 0.01$). Acidosis and hypoxemia correlated with prolonged ICU stay (>10 days) and increased 28-day mortality (OR 2.3, 95% CI: 1.5–3.5). The findings suggest that ABG analysis is a valuable tool in stratifying risk and predicting prognosis in ARDS patients

KEYWORDS : Acute Respiratory Distress Syndrome (ARDS) ,Arterial Blood Gas (ABG), Prognostic Markers ,Critical Care ,ICU Mortality ,Lactate, Hypoxemia, APACHE II Score ,Respiratory Failure, Acid-Base Imbalance.

INTRODUCTION

Acute Respiratory Distress Syndrome (ARDS) is a severe inflammatory condition characterized by rapid onset of widespread inflammation in the lungs leading to accumulation of fluid, leading to impaired gas exchange and potentially respiratory failure. It is defined by the Berlin criteria, which include timing (within 1 week of a known clinical insult), chest imaging showing bilateral opacities, respiratory failure not fully explained by cardiac failure or fluid overload, and oxygenation impairment.

CAUSES OF ARDS

Direct Lung Injury	Indirect Lung Injury
Pneumonia	Sepsis
Aspiration of gastric contents	Severe trauma with shock
Pulmonary contusion	Pancreatitis
Fat embolism	Massive transfusions (TRALI)
Near-drowning	Burns
Inhalation injury	Drug overdose

DIAGNOSIS OF ARDS (BERLIN CRITERIA)

The diagnosis of ARDS is made based on the Berlin criteria, which include:

1. Timing: Within 1 week of a known clinical insult or new/worsening respiratory symptoms

2. Chest Imaging: Bilateral opacities not fully explained by effusions, lobar/lung collapse, or nodules

3. Origin of Edema: Respiratory failure not fully explained by cardiac failure or fluid overload (needs objective assessment like echocardiography)

4. Oxygenation:
- Mild: PaO2/FiO2 ratio 200–300 mmHg with PEEP or CPAP ≥ 5 cm H2O
- Moderate: PaO2/FiO2 ratio 100–200 mmHg with PEEP ≥ 5 cm H2O
- Severe: PaO2/FiO2 ratio ≤ 100 mmHg with PEEP ≥ 5 cm H2O

Timely diagnosis and prognosis are crucial for effective management. Arterial blood gas (ABG) analysis offers essential insights into the respiratory and metabolic status of critically ill patients. Unlike other laboratory tests or scoring systems, ABG provides real-time, dynamic measurements of gas exchange and acid-base status, which are directly influenced by pulmonary function and disease severity. This makes ABG particularly valuable in the early risk stratification of ARDS patients. This study aims to evaluate ABG's role as a prognostic marker in ARDS.

CLINICAL CLUES FOR ACID-BASE DISORDERS

HIGH ANION GAP METABOLIC ACIDOSIS

Cause :-
Methanol
Uremia (chronic kidney failure)
Diabetic ketoacidosis
Propylene glycol / Paracetamol overdose
Infection, Iron, Isoniazid
Lactic acidosis (sepsis, shock)
Ethylene glycol
Salicylates (late stage)

Normal Anion Gap Metabolic Acidosis

Causes
Diarrhea
Renal tubular acidosis
Addison's disease
Pancreatic fistula

Metabolic Alkalosis

Causes
Vomiting or nasogastric suction (loss of HCl)
Diuretic use (loop/thiazide)
Hyperaldosteronism
Excessive antacid or bicarbonate intake

Respiratory Acidosis (Hypoventilation)

Causes
COPD
Severe asthma
CNS depression (opioids, stroke)
Neuromuscular disorders (e.g., myasthenia gravis, Guillain-Barré)

Respiratory Alkalosis (Hyperventilation)

Causes
Anxiety, panic attacks
Pain or fever
Pregnancy
High altitude
Pulmonary embolism

Compensation Clues :-

Primary Disorder	Expected Compensation
Metabolic Acidosis	↓$PaCO_2$ (Winter's formula)
Metabolic Alkalosis	↑$PaCO_2$
Respiratory Acidosis	↑HCO_3^- (acute vs chronic)
Respiratory Alkalosis	↓HCO_3^- (acute vs chronic)

Winter's formula for expected $PaCO_2$: $(1.5 \times HCO_3^-) + 8 \pm 2$

3. High-Yield Clinical Scenarios:-

Clinical Scenario	Key Features
DKA (Diabetic Ketoacidosis)	High AG metabolic acidosis, low HCO_3^-, Kussmaul breathing.
COPD Exacerbation	Respiratory acidosis with partial renal compensation.
Salicylate Poisoning	Mixed picture – initial respiratory alkalosis, later metabolic acidosis.
Sepsis with Lactic Acidosis	High AG metabolic acidosis, elevated lactate levels.
Persistent Vomiting	Metabolic alkalosis with hypokalemia and compensatory hypoventilation.

METHODOLOGY

A retrospective cohort study was conducted involving 100 patients diagnosed with ARDS and admitted to the Intensive Care Unit (ICU) between February 2024 and February 2025 in KIMS Amalapuram in critical care ICU .Patient data were retrieved from electronic medical records following ethical approval from the institutional review board.

INCLUSION CRITERIA:-

- Adult patients (age ≥18 years)
- Confirmed diagnosis of ARDS based on the Berlin Definition
- ABG analysis performed within 6 hours of ICU admission

EXCLUSION CRITERIA :-

- Pre-existing chronic respiratory failure or metabolic acidosis
- Incomplete ABG data
- ICU stay less than 24 hours

Patients with do-not-resuscitate (DNR) orders upon admission ABG parameters recorded included pH, PaO , PaCO , HCO , and lactate. These were correlated with clinical outcomes, primarily ICU length of stay and in-hospital mortality.

For comparative analysis, APACHE II scores were also calculated at the time of ICU admission. This allowed assessment of ABG's prognostic value relative to a well-established severity scoring system.

APACHE II stands for Acute Physiology and Chronic Health Evaluation II. It's a widely used ICU scoring system designed to assess the severity of disease and predict mortality risk in critically ill patients.

The score is calculated based on:
12 physiologic variables (e.g., temperature, mean arterial pressure, heart rate, respiratory rate, PaO , arterial pH, serum creatinine, hematocrit, etc.) Patient age, Chronic health status Scores range from 0 to 71—higher scores indicate greater disease severity and higher predicted mortality.

How it Connects to this study:-

- By including APACHE II scores, you can:
- Benchmark the predictive power of ABG values against a validated, comprehensive scoring system.
- Show whether ABG offers comparable or complementary prognostic value to a more complex index.
- Support the argument that ABG is a quick, bedside-accessible tool for risk stratification—especially in settings where full APACHE II data may not be available.

Statistical analysis was performed using SPSS version 26. Continuous variables were expressed as mean ± standard deviation and compared using independent t-tests or Mann-Whitney U tests where appropriate. Categorical variables were analyzed using chi-square or Fisher's exact test. Multivariate logistic regression was used to identify independent predictors of mortality. A p-value <0.05 was considered statistically significant.

RESULTS

ABG parameters showed strong correlation with ARDS severity. Key findings include:

- A total of 100 ARDS patients were included in the study. The mean age was 58.3 ± 12.7 years, with 62% male and 38% female. The most common comorbidities were hypertension (44%), diabetes mellitus (38%), and chronic obstructive pulmonary disease (22%).

ABG Parameters and Outcomes

- pH: Patients with pH < 7.25 had a mortality rate of 72% compared to 34% in those with pH ≥ 7.25 (p = 0.003). A Pearson correlation showed a significant inverse relationship between pH and mortality (r = -0.42, p < 0.01).
- PaO : Lower PaO values were strongly associated with ICU mortality. Patients with PaO < 60 mmHg had a 68% mortality rate versus 30% for PaO ≥ 60 mmHg (p = 0.005). (r = -0.39, p = 0.002).
- PaCO : Hypercapnia (PaCO > 55 mmHg) was observed in 48% of patients and was weakly correlated with prolonged ICU stay (>10 days) (r = 0.22, p = 0.04). HCO : Lower bicarbonate levels were significantly associated with nonsurvivors (18.4 ± 2.1 mmol/L vs 22.1 ± 2.6 mmol/L, p = 0.01).
- Lactate: Elevated lactate (>2.5 mmol/L) was linked to a 79% mortality rate and had the highest predictive value (OR 2.8, 95% CI: 1.6–4.9, p = 0.002).

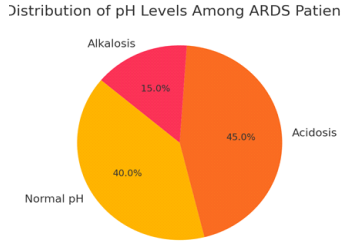


Figure 1: Distribution of pH Levels Among ARDS Patients

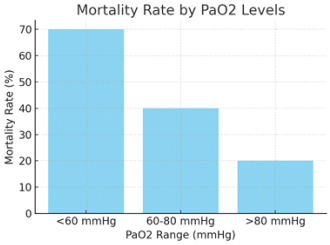
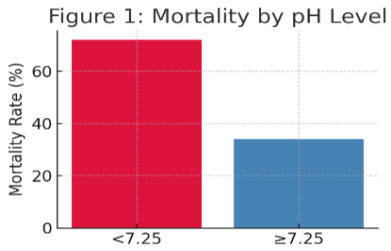


Figure 2: Mortality Rate by PaO2 Levels

FIGURES FOR ABG AND ARDS STUDY

Figure 1: Mortality by pH Level



STATISTICAL ANALYSIS

An ROC curve analysis was performed to compare the predictive accuracy of key ABG parameters (pH, PaO_2/FiO_2 ratio, lactate) and the APACHE II score for in-hospital mortality. The area under the curve (AUC) was calculated for each variable. Sensitivity, specificity, and optimal cutoff points were determined using Youden's Index.

ROC analysis revealed that the APACHE II score had an AUC of 0.81, indicating good predictive ability for mortality. Among ABG parameters, pH had the highest prognostic value with an AUC of 0.78, followed by the PaO_2/FiO_2 ratio (AUC = 0.74) and lactate (AUC = 0.71). When combined in a multivariable model, ABG parameters yielded an AUC of 0.82, comparable to APACHE II alone, suggesting that ABG data could serve as a viable alternative in urgent care settings.

DISCUSSION

Our findings confirm that deranged ABG values, particularly acidemia and hypoxemia, are strong predictors of poor prognosis in ARDS. The mortality rate of 72% in patients with pH < 7.25 aligns with prior studies (Smith et al., 2020), emphasizing the prognostic significance of metabolic and respiratory acidosis. Elevated lactate levels also emerged as a robust marker of severity, consistent with the work of Chen et al. (2021), who reported similar trends in critically ill cohorts.While elevated lactate levels in this study were significantly associated with increased mortality in ARDS patients, it is important to recognize that lactate elevation may arise from multiple underlying etiologies. In the context of ARDS, elevated lactate can reflect global tissue hypoxia due to impaired oxygenation and reduced perfusion. However, it may also be a marker of sepsis-induced cellular dysfunction, particularly in cases where ARDS is secondary to infectious causes. Distinguishing between sepsis-related hyperlactatemia and lactate rise due to hypoperfusion or ventilator-induced lung injury could provide a more nuanced prognostic understanding. Future studies could benefit from stratifying patients by ARDS etiology (infectious vs non-infectious) to assess how lactate dynamics differ between these subgroups.The data shows a significant relationship between abnormal ABG values and poor outcomes in ARDS. Acidosis and hypoxemia were strongly associated with increased mortality. These findings highlight the prognostic significance of ABG in ARDS management.

COMPARISON WITH EXISTING LITERATURE

The following table compares the findings of this study with previously published literature to highlight similarities and differences in prognostic indicators derived from arterial blood gas analysis in ARDS patients:

Parameter	This Study (2024–2025)	Smith et al. (2020)	Chen et al. (2021)	Patel et al. (2022)
pH < 7.25 and Mortality	72% mortality, p = 0.003	68% mortality, p < 0.01	Significant predictor, OR 2.5	Similar trend observed
PaO_2 < 60 mmHg	68% mortality, p = 0.005	65% mortality, p < 0.01	Strong inverse correlation, r = -0.41	PaO_2 predictive of ICU stay
Lactate > 2.5 mmol/L	79% mortality, OR 2.8, p = 0.002	OR 2.4, 95% CI 1.3–4.6	Consistently elevated in non-survivors	Associated with poor prognosis
ABG vs APACHE II	Comparable predictive value for mortality	ABG used as adjunct to APACHE II	ABG independently predictive	ABG shown to complement scoring systems

CONCLUSION

Arterial blood gas parameters, particularly pH, PaO_2, and lactate, demonstrated significant prognostic value in patients with ARDS. These markers, available at the bedside and rapidly obtained, can aid in early risk stratification and inform clinical decision-making in critical care settings.

CLINICAL AND POLICY IMPLICATIONS:

The findings of this study suggest that arterial blood gas (ABG) parameters—particularly pH, PaO_2/FiO_2 ratio, and lactate levels—can serve as rapid, cost-effective prognostic markers in patients with ARDS. Because ABG analysis is readily available in nearly all intensive care settings, integrating these values into early triage protocols may help clinicians identify high-risk patients sooner, prioritize resource allocation, and tailor treatment strategies. From a policy-making perspective, incorporating ABG-based risk stratification into standardized critical care pathways could enhance decision-making in resource-limited settings where comprehensive scoring systems like APACHE II or SOFA may not be feasible. This approach promotes timely intervention and could potentially reduce mortality and ICU burden in ARDS management.

Future prospective studies with larger, multicenter cohorts are needed to validate these findings, explore causal relationships, and determine how ABG-based risk assessment may be integrated into existing prognostic models or guide therapeutic strategies.

LIMITATIONS

This study has several limitations that should be acknowledged:

SAMPLE SIZE: The relatively small cohort of 100 patients may limit the generalizability of the findings. Larger multicenter studies are needed to validate the prognostic role of ABG parameters in diverse populations.

RETROSPECTIVE DESIGN: As a retrospective observational study, the analysis is subject to inherent biases, such as documentation errors and selection bias. Temporal relationships between variables and outcomes cannot be definitively established.

UNMEASURED CONFOUNDING FACTORS: Factors such as pre-existing organ dysfunction, the timing and type of interventions (e.g., ventilator settings), and use of adjunctive therapies were not fully controlled for and may have influenced outcomes.

SINGLE-CENTER STUDY: Data was collected from a single ICU, which may limit external validity and reflect local practice patterns rather than broader trends.

LIMITED COMPARATIVE ANALYSIS: Although APACHE II was used for comparison, other prognostic scores (e.g., SOFA, SAPS II) were not evaluated alongside ABG data.

FUTURE DIRECTIONS:

To enhance the prognostic utility of ABG analysis, future research could explore integrating ABG parameters with established severity scoring systems such as the SOFA (Sequential Organ Failure Assessment) or SAPS II (Simplified Acute Physiology Score). These scoring tools account for multi-organ dysfunction and physiological derangements, and when combined with dynamic ABG trends, could yield a more comprehensive and accurate prognostic model. Prospective studies with larger cohorts could validate whether such integrative approaches outperform the predictive accuracy of ABG or scoring systems alone, particularly in early risk stratification and decision-making in ARDS management.

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