Section: Miscellaneous

Original Research Article

UTILITY OF PERIPHERAL VENOUS BLOOD GAS ANALYSIS IN ACUTE EXACERBATION OF CHRONIC OBSTRUCTIVE PULMONARY DISEASE

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ABSTRACT

Background: Acute exacerbation of chronic obstructive pulmonary disease (AECOPD) is a common cause of emergency department visits and hospital admissions. Arterial blood gas (ABG) analysis is routinely used to assess ventilation, oxygenation, and acid–base status, but arterial sampling is invasive, painful, and technically demanding. Peripheral venous blood gas (VBG) analysis has been proposed as a less invasive alternative for initial assessment. **Objectives:** To evaluate the utility of peripheral venous blood gas analysis in assessing acid–base status and ventilation in patients with acute exacerbation of COPD. **Materials and Methods:** A hospital-based cross-sectional observational study was conducted among patients admitted with AECOPD. Simultaneous arterial and peripheral venous blood samples were collected and analyzed for pH, partial pressure of carbon dioxide (pCO_2), partial pressure of oxygen (pO_2), and bicarbonate (HCO_3^-). Oxygen saturation was assessed using pulse oximetry. Agreement between arterial and venous parameters was assessed using Bland–Altman analysis. **Results:** Venous pH and bicarbonate values showed strong agreement with arterial values. Venous pCO_2 values were slightly higher than arterial values but were clinically acceptable for screening hypercapnia. Venous pO_2 showed poor agreement with arterial pO_2. Pulse oximetry reliably reflected arterial oxygen saturation. **Conclusion:** Peripheral venous blood gas analysis combined with pulse oximetry can be used for initial assessment of acid–base status and ventilation in AECOPD, while ABG analysis should be reserved for selected patients requiring precise assessment of oxygenation.

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a leading cause of morbidity and mortality worldwide and represents a significant public health burden. Acute exacerbations of COPD (AECOPD) are pivotal events in the disease course and are associated with accelerated decline in lung function, impaired quality of life, frequent hospitalizations, and increased mortality. Early identification of respiratory failure during an exacerbation is essential to guide timely and appropriate management.

Patients with AECOPD commonly present with worsening dyspnea, hypoxemia, hypercapnia, and varying degrees of respiratory acidosis. Blood gas analysis plays a central role in evaluating these patients by providing objective information regarding ventilation, oxygenation, and acid–base balance. Arterial blood gas (ABG) analysis has traditionally been considered the gold standard investigation and is recommended by international guidelines to assess the severity of respiratory failure and to guide decisions regarding ventilatory support. Despite its clinical utility, arterial blood sampling has several limitations. It is invasive, painful, and requires technical expertise. Complications such as hematoma, arterial spasm, thrombosis, and infection, although uncommon, are well recognized. In busy emergency departments and resource-limited settings, routine arterial sampling may delay clinical decision-making and increase patient discomfort, particularly when repeated measurements are required.

Peripheral venous blood gas (VBG) analysis offers several practical advantages. Venous sampling is easier to perform, less painful, and associated with fewer complications. Venous blood samples can also be obtained simultaneously with routine laboratory

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investigations, making VBG analysis particularly attractive in emergency and primary care settings. Over the past two decades, several studies have evaluated the correlation between arterial and venous blood gas parameters in various clinical scenarios, including respiratory failure and sepsis.

Most studies have demonstrated strong correlation between arterial and venous pH and bicarbonate values, suggesting that venous samples adequately reflect systemic acid–base status. Venous pCO_2 has also been shown to correlate reasonably well with arterial pCO_2 and may be useful as a screening tool for hypercapnia. In contrast, venous pO_2 has consistently shown poor correlation with arterial pO_2 and is therefore unreliable for assessing oxygenation. Pulse oximetry provides a non-invasive and widely available method for assessing oxygenation and has been shown to correlate well with arterial oxygen saturation in most clinical settings. Combining VBG analysis with pulse oximetry may therefore provide sufficient information for initial assessment while minimizing the need for arterial puncture.

Despite growing international evidence, data from Indian settings evaluating the utility of VBG analysis in AECOPD remain limited. The present study was undertaken to evaluate the role of peripheral venous blood gas analysis in patients with acute exacerbation of COPD and to assess its potential utility in routine clinical practice.

Objectives

1. To evaluate the correlation between arterial and peripheral venous blood gas parameters in patients with acute exacerbation of COPD.
2. To assess the utility of venous blood gas analysis in the initial evaluation of acid–base status and ventilation in AECOPD.
3. To determine the limitations of venous blood gas analysis in assessing oxygenation in AECOPD.

MATERIALS AND METHODS

Study design and setting: This multicentric hospital-based cross-sectional observational study was conducted over a period of 6 months from July 2025 to December 2025 in two tertiary care teaching hospitals in South India

Study Population: Patients admitted with a clinical diagnosis of acute exacerbation of chronic obstructive pulmonary disease were included.

Inclusion Criteria: We included patients aged greater than 18 years who were diagnosed of acute exacerbation of COPD. We did blood gas analysis as part of routine clinical management.

Exclusion Criteria: Those who were hemodynamically unstable or shock, pregnancy, chronic renal failure and severe cardiac disease

Sample Collection: Simultaneous arterial and peripheral venous blood samples were obtained at presentation. Arterial samples were collected from the radial artery using pre-heparinized syringes under aseptic precautions. Venous samples were obtained from the antecubital vein. Samples were analyzed immediately.

Parameters Analyzed: pH, pCO_2, pO_2, and bicarbonate (HCO_3^-) were measured using a blood gas analyzer. Oxygen saturation was assessed using pulse oximetry.

Statistical Analysis: Continuous variables were expressed as mean ± standard deviation. Agreement between arterial and venous parameters was assessed using Bland–Altman analysis. A p value less than 0.05 was considered statistically significant.

RESULTS

Table 1: Demographic characteristics of patients with acute exacerbation of COPD in a study in a tertiary care Hospital in South India

Variable	Number	Percentage (%)
Age ≥45 years	65	92.9
Male	55	78.6
Female	15	21.4

Table 1 describes the demographic profile of patients admitted with acute exacerbation of chronic obstructive pulmonary disease. The majority of patients were aged 45 years and above (65 patients, 92.9%), indicating that acute exacerbations predominantly occurred in older adults. This finding is consistent with the chronic and progressive nature of COPD, which typically manifests with increasing severity in later decades of life.

There was a marked male predominance, with 55 male patients (78.6%) compared to 15 female patients (21.4%). This gender distribution reflects the higher prevalence of COPD among males.

Table 2: Comparison of arterial and venous blood gas parameters in patients with acute exacerbation of COPD in a study in a tertiary care Hospital in South India

Parameter	Arterial (Mean ± SD)	Venous (Mean ± SD)	Mean Difference	p value
pH	7.39 ± 0.05	7.38 ± 0.05	0.01	0.04
pCO_2 (mmHg)	58.6 ± 9.2	61.0 ± 9.0	−2.4	<0.001
HCO_3^- (mEq/L)	34.9 ± 4.1	36.2 ± 3.9	−1.3	<0.001

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Table 2 compares arterial and venous blood gas parameters exclusively in patients with acute exacerbation of COPD. Venous pH and bicarbonate values showed minimal but statistically significant differences from arterial values; however, these differences were not clinically meaningful. Venous pCO_2 values were consistently higher than arterial values, reflecting physiological venous carbon dioxide accumulation, but remained suitable for screening hypercapnia. These findings support the selective use of venous blood gas analysis for initial assessment of acid–base status and ventilation in AECOPD.

DISCUSSION

The present study evaluated the utility of peripheral venous blood gas (VBG) analysis in patients presenting with acute exacerbation of chronic obstructive pulmonary disease (AECOPD). The findings demonstrate that venous pH and bicarbonate values closely approximate arterial values, supporting the use of VBG analysis for assessment of systemic acid–base status in this clinical setting. These findings are consistent with previous studies conducted in emergency and critical care environments, which have reported strong agreement between arterial and venous pH and bicarbonate measurements.[6-8]

Accurate assessment of acid–base status is critical in AECOPD, as respiratory acidosis is a key indicator of disease severity and an important determinant of the need for ventilatory support. International guidelines emphasize the role of blood gas analysis in identifying patients who may benefit from non-invasive ventilation.[1,4] The minimal arterial–venous difference in pH observed in the present study suggests that venous sampling can reliably identify acidemia at presentation and guide early management decisions, particularly in patients with mild to moderate exacerbations.

Venous pCO_2 values in the present study were consistently higher than arterial values, which is physiologically expected due to tissue carbon dioxide production and venous return. Importantly, the magnitude of this difference was clinically acceptable for screening hypercapnia. Several previous studies have demonstrated that venous pCO_2 can be used to identify patients with arterial hypercapnia, thereby reducing the need for routine arterial sampling.[9-11] McKeever et al. reported that venous pCO_2 had good diagnostic accuracy for detecting arterial hypercapnia in AECOPD, supporting its use as a screening tool.[11] The findings of the present study further reinforce this approach.

Hypercapnia is a major determinant of prognosis in AECOPD and is closely associated with the need for ventilatory support and increased mortality.[2,3] Early identification of hypercapnia using a less invasive method such as venous blood gas analysis may facilitate timely escalation of care while minimizing patient discomfort. Patients with markedly elevated venous pCO_2 values can be prioritized for arterial blood gas analysis and closer monitoring, whereas those with near-normal venous values may be managed initially without arterial puncture.

In contrast to pH and pCO_2, venous pO_2 showed poor agreement with arterial pO_2, reaffirming that venous oxygen tension cannot be used to assess oxygenation. This limitation of VBG analysis has been consistently reported in the literature and reflects fundamental physiological differences between arterial and venous blood.[7,12] Reliance on venous pO_2 alone may therefore lead to misinterpretation of hypoxemia and inappropriate clinical decisions.

Pulse oximetry provides a practical and non-invasive solution to this limitation. Several studies have demonstrated good correlation between pulse oximetry-derived oxygen saturation and arterial oxygen saturation in patients with acute respiratory illness.[13] In the present study, oxygenation assessment using pulse oximetry effectively complemented venous blood gas analysis, allowing for reliable evaluation of both ventilation and oxygenation without routine arterial sampling.

From a clinical and health-system perspective, the findings of this study support a pragmatic VBG-first approach in the initial assessment of patients with AECOPD. Such an approach may reduce patient discomfort, lower the risk of procedure-related complications, and improve workflow efficiency in busy emergency departments. These advantages are particularly relevant in resource-limited settings, where access to arterial blood gas analyzers and trained personnel may be constrained.

The role of primary care physicians and family medicine practitioners in the early management of COPD exacerbations is increasingly recognized. Simplifying the initial assessment process without compromising diagnostic accuracy aligns well with the principles of primary care, which emphasize patient-centred, efficient, and minimally invasive care. Incorporating venous blood gas analysis into routine practice may therefore facilitate early decision-making, timely referral, and rational use of healthcare resources.

The present study has certain limitations. The sample size was modest, and the study was conducted at a limited number of centres, which may affect the generalizability of the findings. Additionally, the study focused exclusively on COPD, and the results may not be applicable to other causes of acute respiratory failure. Despite these limitations, the study provides valuable evidence from an Indian clinical setting supporting the selective use of venous blood gas analysis in AECOPD.

Overall, the findings of this study suggest that peripheral venous blood gas analysis, when combined with pulse oximetry, can serve as a reliable and less invasive alternative to arterial blood gas analysis for the initial evaluation of patients with acute exacerbation of COPD. Larger multicentric studies are warranted to further validate these

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findings and to establish standardized protocols for the use of venous blood gas analysis in routine clinical practice.[14]

CONCLUSION

Peripheral venous blood gas analysis, when combined with pulse oximetry, can be safely used for the initial assessment of acid–base status and ventilation in patients with acute exacerbation of COPD. Arterial blood gas analysis should be reserved for selected patients requiring precise assessment of oxygenation or advanced ventilatory support.

Strengths: We simultaneously evaluated arterial and venous sampling. The focus is on a common and clinically relevant emergency condition**.** This can be practically applied in primary care and emergency settings

Limitations: This study has a relatively small sample size. The findings may not be applicable to non-COPD causes of respiratory failure.

Recommendations: Peripheral venous blood gas analysis may be used as the initial investigation for evaluating acid–base status and ventilation in patients presenting with acute exacerbation of chronic obstructive pulmonary disease, particularly in emergency and primary care settings. Arterial blood gas analysis should be reserved for patients with severe hypoxemia or clinical deterioration. Pulse oximetry should be routinely combined with VBG analysis. Institutional protocols may be developed to guide clinicians on the appropriate use and interpretation of venous blood gas analysis, and training programs should emphasize its role and limitations in acute COPD management.

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