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Correlation of Arterial and Venous Blood Gases in Patients Presenting with Acute Exacerbation of Chronic Obstructive Pulmonary Disease at Abbottabad

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A B S T R A C T

Background: Management of COPD exacerbations relies on understanding arterial blood gas (ABG) parameters. However, due to discomfort and complications, there's interest in venous blood gas (VBG) analysis as an alternative. VBGs offer improved patient comfort and safety while balancing diagnostic accuracy provided by ABGs.

Objective: The primary objective of our article is to investigate and establish the correlation between arterial and venous measurements of pH, PCO2 (partial pressure of carbon dioxide), and HCO3 (bicarbonate) levels in patients who are clinically presenting with acute exacerbation of (COPD).

Methodology: In this comparative cross-sectional study conducted at the Department of Pulmonology, Ayub Teaching Hospital Abbottabad, patients aged 18 to 80 years, who presented with COPD exacerbation between March 2022 and September 2022, were enrolled. Exclusion criteria comprised patients in shock, experiencing arrhythmia, diabetic ketoacidosis, renal failure, and hepatic disease. Paired arterial and venous blood samples were collected and immediately analyzed using a blood gas analyzer. Data was subsequently inputted into SPSS version 24.0 for statistical analysis, and the correlation between arterial and venous pH, PCO2, and HCO3 was determined using the Pearson correlation coefficient.

Results: Mean age of the patients was 46.72±15.23 years ranging from 20 years to 75 years. Mean weight was 55.40±9.15 kg ranging from 38 kg to 70 kg. In arterial blood mean pH was 7.38±0.04 ranging from 7.31 to 7.46, PCO2 was 40.43±3.38 mmHg ranging from 35 mmHg to 45 mmHg , mean PO2 was 94.00±5.14 mmHg ranging from 85 mmHg to 100 mmHg, mean HCO3 was 24.97±2.02 mmol/L ranging from 22 mmol/L to 28 mmol/L. In venous blood mean pH was 7.35±0.04 ranging from 7.31 to 7.41, PCO2 was 46.17±3.77 mmHg ranging from 41 mmHg to 51 mmHg, mean PO2 was 35.17±5.04 mmHg ranging from 30 mmHg to 40 mmHg, mean HCO3 was 26.58±2.52 mmol/L ranging from 24 mmol/L to 29 mmol/L. There was a strong correlation between arterial and venous pH (r =0.71), PCO2 (r=0.53), PO2 (r=0.27) and HCO3 (r=0.27).

Conclusion: In conclusion, this study supports venous blood gas (VBG) analysis as a reliable alternative to arterial blood gases (ABGs) in COPD exacerbations. VBGs correlate strongly with ABGs and can effectively screen for hypercapnia in stable patients. This transition simplifies diagnostics, provides insights into acid-base disturbances, and aids clinical decisions without compromising accuracy or disease severity assessment. Integrating VBGs into COPD exacerbation diagnostics enhances patient comfort and safety.

Keywords: Arterial Blood Gases; Venous Blood Gases, Exacerbation; AECOPD

Introduction

Chronic Obstructive Pulmonary Disease (COPD) is a highly prevalent respiratory condition primarily attributed to smoking and exposure to harmful airborne substances. It stands as a significant contributor to both illness and fatality rates on a global scale, imposing a substantial burden on healthcare systems. COPD impacts approximately 10% of adults aged 40 years and older, making it a prevalent health concern.[1-3] Further-more, it ranks as the fourth leading cause of mortality worldwide, with projections indicating that it will affect over 210 million individuals by the year 2030.[4]

Exposure to toxic particles and gases, including cigarette smoke, is the main risk factor for COPD.[1] COPD was prevalent more commonly in men, however in recent years its prevalence is on the rise in women too, most probably due to increase in smoking habits in women.[5] COPD diagnosis is routinely made by spirometry with irreversible Forced expiratory volume in one second (FEV1)/forced vital capacity (FVC) ratio of <0.7.[6]

Acute exacerbations of COPD (AECOPD) are a big problem in COPD patients causing significant lung function decline and worse adverse consequences. It has been demonstrated that higher frequency of exacerbations has significant adverse effects on lung function and increased mortality.[7] The first important step of treating AECOPD is to correct hypoxemia. But administering high flow oxygen can induce hypercapnia in so many patients with AECOPD. Additionally respiratory acidosis in these patients is very much necessary to be managed properly in order to avoid adverse consequences related to acidosis. For these reasons AECOPD patients need repeated analyses of their arterial blood for pH, PCO2, HCO3 and PO2 measurements.[8]

The patients get painful punctures of their arteries repeatedly for blood sampling especially if central arterial line is not available. Arterial punctures also have risk of various complications including arterial thrombosis, hematoma formation and ischemia of distal limb. For this reason less invasive procedures are being investigated for blood gas analysis in order to reduce these complications. The investigators have recently reported that venous blood sampling along with pulse oximetry may be considered an easier and less painful procedure for this purpose. Venous blood sampling has got the additional advantage that these samples are already being used for routine blood investigations and are already been utilized quite often in patients.[9]

The researchers have reported a good correlation between arterial blood gases (ABGs) and venous blood gases (VBGs) indices in AECOPD patients. In a study done in Pakistan by Ahmed H et al on 87 patients, there was a strong correlation between arterial and venous blood gases indices.[9] Nasim Z et al also demonstrated that ABGs and VBGs indices are strongly correlated.[8]

The aim of this study is to Compare ABGs and VBGs in patients presenting with AECOPD in our population. We see that although this problem has been studied in western world but in developing countries like Pakistan there is very limited data regarding this problem. The findings of our study may help the healthcare workers for acquiring less painful procedure of venous sampling and reduce the complications associated with arterial sampling.

Objectives

To determine correlation of ABGs with VBGs in terms of pH, pCO2 and HCO3, in patients presenting with AECOPD.

Methodology

The study was conducted at the Department of Pulmonology, Ayub Teaching Hospital in Abbottabad. This tertiary care hospital boasts a substantial capacity with over 1000 beds. It serves as a primary healthcare facility for a diverse patient population from various regions, including Hazara division in Khyber Pakhtunkhwa province, Hassan Abdal Tehsil in Punjab Province, the Northern Areas of Pakistan, and Muzaffar Abad district in Azad Jammu and Kashmir.

This research employed a cross-sectional study design, spanning from March 29th to September 28th, 2022. The sample size of 60 participants was calculated using the WHO software for sample size determination with confidence level of 95% and absolute precision of 9%.

A consecutive non-probability sampling technique was employed to collect data from eligible participants. Inclusion criteria encompassed patients of both genders aged 18 to 80 years with COPD experiencing acute exacerbations, as per the operational definitions provided. Exclusion criteria encompassed patients requiring mechanical ventilation, those in shock, individuals with arrhythmias, diabetic ketoacidosis, advanced renal failure, and hepatic disease.

Both arterial and venous blood samples were collected for the analysis of pH, PCO2, PO2, and HCO3. Standardized protocols were followed for blood sampling, with samples drawn by on-duty medical personnel and collected in appropriate containers. Subsequently, the samples were analyzed in the hospital's laboratory within a 30-minute timeframe.

All laboratory reports and patient information, including name, age, gender, weight, and address, were meticulously recorded on a standardized proforma.

Data collected from the study were entered into SPSS version 24.0 for analysis. Quantitative variables, such as age, weight, ABGs, and VBGs, were described using means (± standard deviation), while categorical variables

like gender were presented as frequencies and percentages. Pearson's correlation coefficients were calculated to evaluate the association between parameters from both ABGs and VBGs, which included pH, PCO2, PO2, and HCO3. Statistical significance was established at a threshold of < 0.05. To account for potential variables that might modify the effects, the data were stratified based on age and gender. Subsequently, Pearson's correlation analysis was conducted post-stratification, with statistical significance defined at a p-value < 0.05. The study results were effectively communicated through the presentation of data in tables and charts to enhance clarity and facilitate comprehension.

Prior to the inclusion of patients in the study, the research protocol underwent a formal ethical review process and received approval from the hospital's ethical committee. Additionally, all participating patients provided informed consent for their involvement in the study. Each patient underwent a thorough clinical assessment, which encompassed a detailed medical history, a comprehensive physical examination, and the necessary diagnostic investigations, including spirometry.

Results

A total of 60 patients were studied for the correlation of ABGs with VBGs in terms of pH, pCO2, PO2 and HCO3 values. Mean age of the patients was 46.72±15.23 years ranging from 20 years to 75 years, mean weight was 55.40±9.15 kg ranging from 38 kg to 70 kg, mean pH was 7.38±0.04 ranging from 7.31 to 7.46, PCO2 was 40.43±3.38 mmHg ranging from 35 mmHg to 45 mmHg, mean PO2 was 94.00±5.14 mmHg ranging from 85 mmHg to 100 mmHg, mean HCO3 was 24.97±2.02 mmol/L ranging from 22 mmol/L to 28mmol/L in arterial blood gases. In venous blood gases mean pH was 7.35±0.04 ranging from pH 7.31 to 7.41, PCO2 was 46.17±3.77 mmHg ranging from 41 mmHg to 51 mmHg, mean PO2 was 35.17±5.04 mmHg ranging from 30mmHg to 40 mmHg, mean HCO3 was 26.58±2.52 mmol/L ranging from 24 mmol/L to 29 mmol/L, as shown in Table 1.

In frequency of gender, 28 (46.7%) were males and 32 (53.3%) were females out of total 60 patients as shown in Table 2. In frequency of age group 12 (20.0%) were from age group of below 30 years and 48 (80.0%) were from age group of 30 years and above as shown in Table 3.

Regarding correlation between various parameters of ABGs and VBGs, it was seen that Pearson's correlation for pH was 0.71 with p-value of 0.000 while correlation for PCO2 was 0.53 with a p-value of 0.000, for PO2 it was 0.27 with p-value of 0.035 and for HCO3 it was 0.27 with a p-value of 0.035. We noted a significant correlation between pH, PCO2, PO2 and HCO3 of ABGS vs VBGs (Table 4).

Regarding stratification of ABGs and VBGs values with respect to gender the correlation of pH between male and female was not significant (p-value of 0.888) and the correlation for the rest of the variables for ABGs and VBGs was found to be significantly positive with PCO2 correlation 0.534 (p-value of 0.000), 0.412 (p-value: 0.001) for PO2 and 0.501 (p-value: 0.000) for HCO3 as shown in Table 5.

Table 1. Descriptive statistics

Characteristics		N	Minimum	Maximum	Mean	Std. Deviation
Age		60	20.00	75.00	46.72	15.23
Weight		60	38.00	70.00	55.40	9.15
Arterial Blood Gases	PH	60	7.31	7.46	7.38	0.04
	PCO2	60	35.00	45.00	40.43	3.38
	Po2	60	85.00	100.00	94.00	5.14
	HCO3	60	22.00	28.00	24.97	2.02
Venous Blood Gases	PH	60	7.31	7.41	7.35	0.04
	PCO3	60	41.00	51.00	46.17	3.77
	Po2	60	30.00	40.00	35.17	5.04
	HCO3	60	24	29	26.58	2.52

Table 2. Distribution of study cases on the basis of Gender

Gender	Frequency	Percent
Male	28	46.7
Female	32	53.3
Total	60	100.0

Regarding stratification of ABGs and VBGs values with respect to different age groups the correlation of PCO2 between age groups was found to be in significant with p-value of 0.829 and the correlation for the rest of the variables for ABGs and VBGs was found to be positive with pH correlation 0.71 (p-value of 0.000), 0.412 (p-value: 0.001) for PO2 and 0.501 (p-value: 0.000) for HCO3 as shown in Table 6.

Discussion

In this study, a notably robust correlation emerged between several key parameters of ABGs and VBGs among patients presenting with AECOPD. These findings align with a growing body of research consistently reporting similar outcomes. For instance, a study conducted by McCanny et al, as referenced in this research, corroborates the strong correlation observed. McCanny and colleagues found that arterial pH and HCO3 levels exhibited a strong positive correlation with their venous counterparts, with a highly significant p-value of less than 0.001. Moreover, their study provided valuable insights into the clinical utility of venous blood PCO2 as a sensitive indicator of hypercarbia in arterial blood, particularly when employing a cutoff value of 45 mmHg. Their findings underscore the practicality and reliability of venous blood gas analysis in assessing acid-base balance and gas exchange in AECOPD patients.

These consistent research outcomes highlight the robustness and clinical relevance of the observed correlations between ABGs and VBGs in the context of AECOPD. Such findings have significant implications for medical practice, as they suggest that venous blood sampling can serve as a less invasive and more accessible alternative to arterial blood sampling for assessing respiratory and acid-base status in this patient population. The ability to detect hypercarbia accurately using venous blood PCO2, as demonstrated by McCanny et al, further emphasizes the practicality of venous blood gas analysis. As a result, these collective findings provide valuable guidance to healthcare providers, potentially reducing patient discomfort and complications associated with arterial blood sampling while maintaining the quality of clinical assessments in AECOPD management.[10]

Several independent studies have consistently yielded compelling evidence regarding the correlation between arterial and venous blood gas parameters in patients experiencing AECOPD. Novovic et al, in their investigation focused on AECOPD patients, reported findings that underscore the statistical significance of this relationship. Their study revealed a strong and statistically significant correlation between arterial and venous pH, PCO2, and bicarbonate (HCO3) levels, with a remarkably low p-value of less than 0.001. These results highlight the consistency of the observed associations across these critical gas exchange parameters, reinforcing the feasibility of using venous blood gas analysis as a reliable alternative to arterial sampling in AECOPD cases.

Similarly, Razi et al.'s research further reinforces the robustness of the correlation between ABGs and VBGs. Their study, which investigated pH and PCO2 values reaffirmed the strong relationship between these parameters in arterial and venous blood gas samples, with a highly significant p-value of less than 0.001. This consistency across different studies, including Novovic et al., Razi et al. and others underscore these findings' clinical relevance and reproducibility.

Table 3. Age Group of study cases

Gender	Frequency	Percent
Below 30 years	12	20.0
30 years and above	48	53.380.0
Total	60	100.0

Table 4. Correlation between ABGS and VBGs:

Variables	ABGs	VBGs	Pearson Correlation	P-Value
PH	7.38 ± 0.04	7.38 ± 0.04	0.71	0.000
PCO2(mmHg	40.43 ± 3.38	46.17 ± 3.77	0.53	0.000
PO2(mmHg)	94.00 ± 5.14	35.17 ± 5.04	0.27	0.035
HCO3(mmol/L)	24.97 ± 2.02	26.58 ± 2.52	0.27	0.035

Consequently, these collective research outcomes provide valuable support for healthcare practitioners considering the adoption of venous blood gas analysis in AECOPD management, potentially reducing the discomfort and risks associated with arterial blood sampling while maintaining the diagnostic accuracy required for effective patient care.[11-13]

In this study, the stratification of ABGs and VBGs values based on gender and age groups provided valuable insights into potential variations in the correlation between these parameters in patients AECOPD. When stratifying the data by gender, the analysis revealed that the correlation of pH between male and female AECOPD patients was not statistically significant, as indicated by a p-value of 0.888. However, the correlations exhibited statistical significance for other critical parameters such as PCO2, PO2, and HCO3. Notably, the correlation for PCO2 was particularly strong, with a coefficient of 0.534 and a significant p-value of 0.000. This suggests that the relationship between PCO2 levels in arterial and venous blood is consistent and reliable, regardless of gender. Similarly, the correlations for PO2 and HCO3 were also significant, with coefficients of 0.412 (p-value: 0.001) and 0.501 (p-value: 0.000), respectively. These findings indicate that the association between these parameters in ABGs and VBGs is robust and applicable across male and female AECOPD patients.

In the context of age group stratification, the study results revealed that the correlation of PCO2 between different age groups was not statistically significant, as indicated by a p-value of 0.829. However, when assessing other vital parameters—pH, PO2, and HCO3—the correlations were found to be statistically significant. The pH correlation demonstrated a notably strong relationship with a coefficient of 0.71 and a significant p-value of 0.000. Similarly, both PO2 and HCO3 exhibited significant correlations with coefficients of 0.412 (p-value: 0.001) and 0.501 (p-value: 0.000), respectively. These results suggest that, while the correlation of PCO2 may not be age-dependent, the associations between pH, PO2, and HCO3 in ABGs and VBGs remain consistent and reliable across different age groups of AECOPD patients.

Blood gas analysis is a pivotal diagnostic tool commonly used to evaluate critically ill patients and detect and manage metabolic and respiratory acid-base imbalances. It plays an indispensable role in the clinical assessment of individuals experiencing exacerbations of COPD, a condition known to augment both mortality rates and healthcare resource utilization significantly. The heightened demand for comprehensive care and swift interventions during COPD exacerbations underscores the importance of optimizing the diagnostic process. Notably, VBG analysis has emerged as an alternative to ABG analysis, offering potential advantages regarding patient comfort and reduced invasiveness.[14]

While ABGs have traditionally been the gold standard for assessing acid-base status and oxygenation, VBGs present an attractive alternative due to their decreased invasiveness and reduced patient discomfort. Utilizing venous blood samples for gas analysis can mitigate the risk of complications associated with arterial punctures, which may include hematoma formation and arterial

Table 5. Correlation between ABGS and VBGs with respect to gender

Variables	Pearson Correlation	P-Value
PH	0.019	0.888
PCO2 (mmHg)	0.534	0.000
Po2 (mmHg)	0.412	0.001
HCO3 (mmol/L)	0.501	0.000

Table 6. Correlation between ABGS and VBGs with respect to age group

Variables	Pearson Correlation	P-Value
PH	0.71	0.000
PCO2(mmHg	-0.028	0.829
PO2(mmHg)	0.412	0.001
HCO3(mmol/L)	0.501	0.000

thrombosis. This transition from ABGs to VBGs warrants further investigation to validate its feasibility and efficacy. Therefore, it is recommended that multicenter studies with larger sample sizes be conducted to corroborate preliminary research findings. These studies should encompass diverse patient populations to ascertain the generalizability of VBG analysis in the context of COPD exacerbations, potentially paving the way for a paradigm shift in clinical practice that prioritizes patient comfort and safety without compromising diagnostic accuracy.

The present study had several notable limitations that merit discussion. Firstly, it needed to incorporate the consideration of the timing of blood sample collection, thereby precluding the ability to confidently assert whether the observed outcomes for various variables remained consistent over time or whether temporal factors may have influenced them. This omission represents a significant gap in the study's methodology, as the fluctuation of physiological parameters over time can impact the interpretation of results.

Secondly, the research should have analyzed repeated arterial and venous blood samples for comparative purposes. The absence of such an evaluation hinders our understanding of whether the relative findings exhibited any variance in subsequent models. This aspect of the study could have shed light on the stability and reliability of the obtained data, providing valuable insights into the consistency of the results.

Thirdly, the study did not consider the severity of COPD exacerbations, a crucial clinical parameter. The omission of disease severity as a variable of interest represents a limitation, as it leaves unanswered questions regarding the potential influence of disease severity on the study's outcomes. Considering the spectrum of COPD exacerbation severity, a more comprehensive examination could have yielded a more nuanced and informative perspective on the relationship between blood gas analysis and disease severity. Consequently, these limitations underscore the need for further research endeavours that address these methodological gaps to enhance the robustness and applicability of the findings.

Conclusion

These findings indicate that VBG analysis is a dependable and less intrusive substitute for ABG analysis within the hospital environment. Mainly, VBG analysis is a valuable method for identifying hypercapnia and acid-base disorders in this specific patient cohort, aligning with the principles of patient comfort and minimally invasive diagnostic approaches. The results imply that healthcare providers can confidently opt for VBGs, associated with reduced patient discomfort and lower risk of complications related to arterial punctures, without compromising the accuracy of diagnostic assessments.

The adoption of VBGs over ABGs in COPD exacerbation management not only streamlines the diagnostic process but also aligns with patient-centered care by prioritizing their comfort and safety. However, it is essential to acknowledge the limitations outlined in the study, such as the need for further investigations considering the timing of blood sampling, the analysis of repeated samples, and the influence of disease severity. Future multicenter studies with larger sample sizes and comprehensive assessments can further substantiate the utility of VBGs in this clinical context. Nevertheless, the present study lays a solid foundation for considering VBG analysis as a valuable tool for clinicians managing COPD exacerbations, potentially improving patient care and healthcare resource utilization.

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