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COMPARISON BETWEEN PERIPHERAL VENOUS BLOOD GAS AND ARTERIAL BLOOD GAS ANALYSIS IN PATIENTS ADMITTED IN RESPIRATORY MEDICINE DEPARTMENT

Respiratory Medicine

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ABSTRACT

Introduction: Arterial blood gas (ABG) analysis is used to evaluate oxygen and carbon dioxide gas exchange and acid-base status. The procedure has certain limitations. Venous blood gas (VBG) analysis is a relatively safer procedure and may be an alternative to ABG analysis. **Materials and Methods:** A cross sectional observational study to investigate the correlation of ABG and peripheral VBG measurements. Patients who were suspected to have respiratory failure were included in this study. The study included 50 patients. **Results:** Our study population consisted of 29 (52%) male and 21 (48%) female with mean age of 57±14. Regression equations were derived to predict arterial values from venous values as follows: Arterial pH = 1.0013x [x = venous pH] (R2 = 0.999), Arterial PCO2 =0.9049x [x = venous PCO2] (R2=0.994), Arterial HCO3 =0.982x [x = venous HCO3] (R2 = 0.995) Arterial PO2=1.825x [x = Venous PO2] (R2 = 0.947). **Conclusions:** Peripheral venous blood gas analysis for pH, PCO2 and bicarbonate may replace their arterial equivalents in many clinical contexts. Though there was significant correlation, venous PO2 cannot substitute arterial PO2 as there was lack of agreement.

KEYWORDS

Arterial blood gas, Venous blood gas, Respiratory failure

INTRODUCTION

Arterial blood gas (ABG) analysis is used to evaluate oxygen and carbon dioxide gas exchange and acid-base status.[1] ABG analysis is indicated in any situation where assessment of arterial blood oxygenation, alveolar ventilation, gas exchange across the lungs or acid base status is required.

As arterial puncture is painful, there is less patient acceptability for this procedure. An arterial puncture may predispose the patient to develop complications like arterial injury, thrombosis with distal ischemia, haemorrhage, aneurysm formation, median nerve damage, and rarely reflex sympathetic dystrophy.[2-4]

A further drawback for healthcare providers is the possibility of a needle stick injury when performing an ABG. A comparatively safer procedure is venous blood gas (VBG) analysis, which poses fewer risks to both the patients and healthcare professionals.[5] The most obvious advantage of obtaining a VBG instead of ABG is decreased pain for the patient.

The purpose of this study was to investigate the correlation of ABG and peripheral VBG samples for all common parameters like pH, partial pressure of carbon dioxide (PCO_2) partial pressure of oxygen (PO_2) and serum bicarbonate (HCO3) level. From this study we would be able to show whether VBG could replace ABG in the assessment of suspected respiratory failure of diverse pathological conditions.

AIMS AND OBJECTIVES

1. To find a correlation between the arterial blood gas (ABG) and venous blood gas (VBG) parameters namely pH, PCO_2, PO_2 and bicarbonate.
2. To determine predictive role of VBG upon ABG.
3. To assess whether in future VBG can replace ABG in disease state.

MATERIALS AND METHODS

A Single centred cross sectional observational study was performed from March, 2021 to April, 2022 at Department of Respiratory Medicine, N.R.S. Medical College and Hospital, Kolkata to evaluate the correlation of ABG and peripheral VBG measurements (pH, PCO_2, PO_2andHco3).

Inclusion Criteria

1. Age > 12 years.
2. Male and female both included.
3. All patients admitted in in RCU (respiratory care unit) and chest indoor with suspected respiratory failure.
4. Samples taken from arterial and venous blood within a time gap of two minutes.

Exclusion Criteria

1. Samples run on different blood gas analyser
2. Samples for ABG and VBG drawn 2 minutes more apart
3. Patients with known primary cardiac disease that cause right to left shunt.
4. Unwilling to give informed written consent.

Fifty patients were included in this study after obtaining written informed consent. Arterial blood sample was drawn with precautions and simultaneously venous blood sample was also obtained within 2 minutes of arterial puncture. For arterial samples, minimally heparinized 2ml plastic syringe of 2ml with 24 G needle was used to puncture the radial artery. For venous sampling, blood was obtained by peripheral venepuncture in aseptic way using minimally heparinized 2ml plastic syringe with 24 G needle. The ABG and VBG samples were analysed immediately on OPTI CCA TS blood gas analyser. The accuracy of blood gas analyser was validated daily.

The Bland- Altman limits of agreements (LOAs) were determined by plotting the difference between 2 paired values (arterial and venous) against their mean, thus creating a bias plot. The 95% LOAs represent the mean difference between each pair of venous and arterial values ± 1.96SD, and they estimate by how much a venous value is likely to differ from the criterion standard, the arterial value. Pearson correlations between ABG and peripheral VBG values were obtained. Equations for the estimation of arterial values from peripheral venous values were ascertained using linear regression. SPSS version18.0 (SPSS, Chicago, IL, USA) was used to conduct our statistical analyses.

RESULTS

The study involved 50 patients who met the inclusion criteria with a total of 50 paired ABG-VBG samples. The mean age of the patients was 57±14 with a range between 14 to 78. The patient population consisted of 29 (52%) male and 21 (48%) female.

Among the study population, majority of cases were diagnosed as AECOPD (acute exacerbation of chronic obstructive pulmonary disease) [17(34%)], followed by pneumonia [9(18%)], bronchiectasis

[9(18%)], ILD (interstitial lung disease) [7 (14%)], malignancy [7 (14%)]. The patient characteristics are shown in Table 1.

Table 1: Patient Characteristics

Patient Characteristics	
Age (years, mean ±SD)	57±14
Sex [male/female; n, (%)]	29 (58%)/21 (42%)
Primary diagnosis: n/N (%)	
AECOPD	17/50 (34%)
Pneumonia	10/50 (20 %)
Bronchiectasis	9/50 (18%)
ILD	7/50 (14%)
Malignancy	7/50 (14 %)

Among 50 patients 5 patients (10%) treated with invasive ventilation, 16 patients (32%) were treated with non-invasive ventilation and 29 (60%) patients were treated conservatively. Table 2 showing the distribution of mode of treatment.

Table 2: Mode of treatment (n=50)

Patient Category	Invasive Ventilation	Non-Invasive Ventilation	Conservative
AECOPD	3	12	2
Pneumonia	1	0	9
Bronchiectasis	0	3	6
ILD	1	1	5
Malignancy	0	0	7
Total	5	16	29

The arterial pH values ranged from 6.86 to 7.69, the arterial PCO_2 values ranged from 27 to 122, arterial HCO3 values ranged from 15.7 to 55.3 and arterial PO_2 ranged from 35 to 172. Venous pH values were 6.83 to 7.65, Venous PCO_2 values were 32 to 124 Venous HCO3 values were 15.7 to 54.9, and venous PO_2 values were 15 to 73. Table 3 shows the mean values and Standard deviation, arterio- venous difference, 95% limits of agreement, correlation coefficient values for arterial and venous pH, PCO_2, HCO3 and PO_2.

Table 3: Arterial and Venous blood gas analysis values: (n= 50)

Para-meter	ABG (Mean ± SD)	VBG (Mean ± SD)	A-V Differentiation (Mean± SD)	Bald Altman 95% LOA	Pearson correlation coefficient (R)
pH	7.4012± 0.117	7.3782± 0.04	0.023± 0.04	-0.048 to 0.094	0.95
PCO 2	56.84± 21.684	62.98± 21.765	-6.14± 4.359	-14.77 to 2.49	0.97
HCO 3	33.928± 9.18	34.528± 8.934	-0.6± 2.246	-5.047 to 3.84	0.96
PO2	79.14± 19.909	41.82± 12.31	37.92± 15.569	7.0949 to 68.745	0.623

Bland-Altman bias plots of arterial and venous pH showed mean bias 0.02 and 95% LOA of -0.04 to 0.09 for A-V difference. The mean bias in PCO_2 was 0.02 and 95% limits of agreement= -0.04 to 0.09. The mean bias in HCO3 was -0.6 and 95% limits of agreement= -5.04 to 3.84. The mean bias in PO_2 was 37.92 and 95% limits of agreement= 7.094 to 68.74.

Figure 1 shows Bland- Altman plots of arterial and venous values. A: pH, B: PCO_2, C: HCO3 and D: PO_2. Solid line is mean line and dotted lines are 95% limit of agreement line.

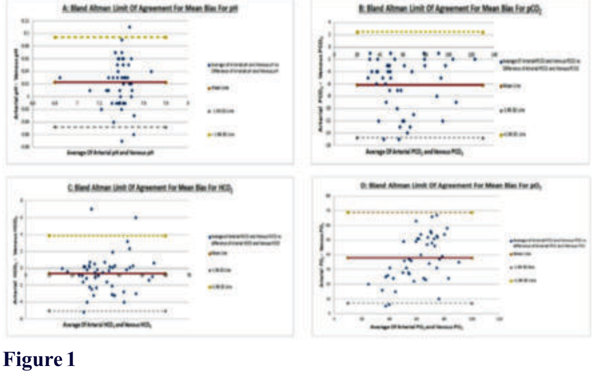

Figure 1

In our study, there was excellent agreement between arterial and venous values for pH, PCO_2 and bicarbonate.

Arterial pH and venous pH were found to be correlated significantly (Pearson's correlation coefficient R= 0.95, 95% confidence interval for R = 0.92 to 0.97, p<0.0001). There was a strong correlation between the arterial and venous PCO_2 (Pearson's correlation coefficient R = 0.97, 95% confidence limits of R = 0.96 to 0.98, p<0.0001). There was also a strong correlation between the arterial and venous HCO3 (R= 0.96, 95% of confidence limits of R = 0.94 to 0.98 p<0.0001). There was also a strong correlation between the arterial and venous PO_2 (R = 0.623, 95% of confidence limits of R = 0.417 to 0.768 p<0.0001).

Figure 2 shows correlation coefficient graphs of arterial and venous values. A: pH, B: PCO_2, C: HCO3 and D: PO_2

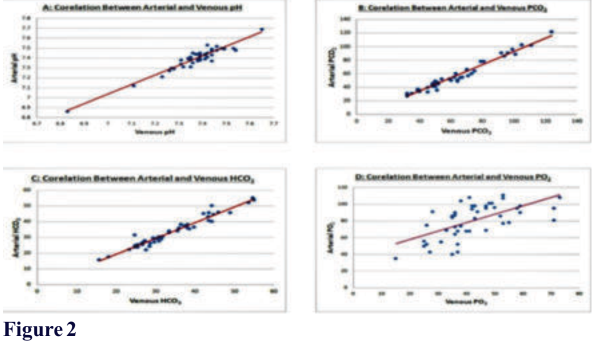

Figure 2

Regression equations were derived to predict ABG values from peripheral VBG values, and are as follows:
Arterial pH = 1.0013x [x= venous pH] (R^2=0.999)
Arterial PCO_2 =0.9049 x [x=venous PCO_2] (R^2=0.994)
Arterial HCO3 =0.982 x [x= venous HCO3] (R^2= 0.995)
Arterial PO_2=1.825 X [X= Venous PO_2] (R^2= 0.947)

Figure 3 shows linear regression analysis graph. A: pH, B: PCO_2, C: HCO3 and D: PO_2

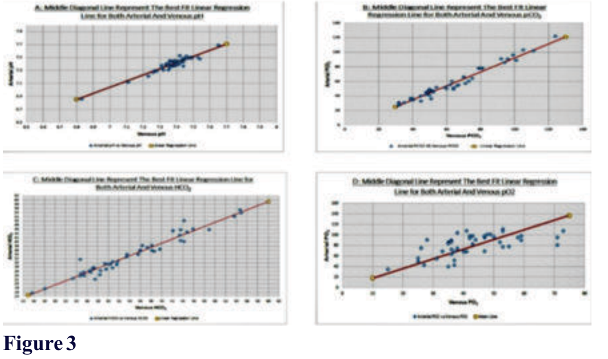

Figure 3

DISCUSSION

The aim of this study was to investigate the correlation between ABG and peripheral VBG samples for all commonly used parameters (pH, PCO_2, PO_2 and bicarbonate) in pathologically diverse patients admitted in respiratory medicine department.

The study involved 50 patients who met the inclusion criteria with a total of 50 paired ABG-VBG samples. The mean age of the patients was 57±14 with a range between 14 to 78. The patient population consisted of 29 (52%) male and 21 (48%) female.

Although the presenting diagnosis for patients in the study was predominantly COPD (34%), there was a range of other pathophysiology present.

With respect to pH, the ABG and VBG values were strongly correlated (R= 0.95, p< 0.0001). The mean arterial minus venous difference for pH was 0.023±0.04 with 95% limits of agreement of -0.048 to 0.094.

Kelly et al demonstrated, very good agreement for pH with venous samples being an average of 0.034 pH units lower than arterial samples.[6] Treger R et al.,[7] also obtained the similar result but their studies compared ABG with central VBG.

For PCO_2 the ABG and VBG values were also correlated strongly (R= 0.97, p<0.0001). We found an acceptable agreement between arterial and venous values for PCO_2, the mean arterial minus venous difference was -6.14±4.359 with 95% limits of agreement of -14.77 to 2.49.

The arterial and venous values for PCO_2 in our study showed better agreement than the study by Kelly et al.[6] which demonstrated mean arterial minus venous difference of -5.8 with 95% limits of agreement of -8.8 to 20.5.

However, there was less agreement in our study compared with studies by Malinoski et al.[8] which showed a mean arterial minus venous difference of -4.36 with 95% limits of agreement of -2.20 to 10.90. Malatesha et al.[9] revealed a mean arterial minus venous difference of -3.0 with 95% limits of agreement of -7.6 to 6.8, and their agreement was found to be better than our findings.

Less agreement in our study may be explained by the fact that in our study there was wide range of PCO2. However, the results of our study in regard to PCO_2 are consistent with the study done by Treger R et al.[7] and Koul PA et al[10].

Regarding bicarbonate, we found the mean arterial minus venous difference was -0.6±2.246 with 95% limits of agreement of -5.047 to 3.847. The correlation between HCO3 values of ABG and VBG was strong (R= 0.96, p< 0.0001) in our study.

Kelly et al described a mean arterial minus venous difference for bicarbonate ranging from -1.88 to -0.52.[6]

In our study, there was a significant correlation between arterial and venous blood gases for PO_2 (R= 0.62, p<0.0001). Bland-Altman 95% LOA between arterial and venous values of PO_2 was 7.094 to 68.74 with A-V difference of 37.92±15.56. Koul PA et al.[10] also described the similar result regarding PO_2. Yildizdas et al.[11] and Ak A et al.[12] reported poor correlation results for PO_2. So, it was not clinically acceptable to support uniform usage of venous PO_2 instead of arterial PO_2 in clinical practice.

Thus, the results of our study may help us to make different formulations. These formulations may be useful for estimating arterial acid-base status in pathologically diverse populations from VBG values. Our study clearly suggested that venous PO_2 cannot replace arterial PO_2 since the arterio-venous difference for PO_2 was too high clinically acceptable.

This study does have some limitations. First, our study was performed in single centre with small number of patients (n=50). Second, most of our patients were suffering from COPD (52%). Representation of other diseases (Bronchiectasis, ILD, Malignancy etc) were small.

CONCLUSION

Peripheral venous blood gas analysis for pH, PCO_2 and bicarbonate may replace their arterial equivalents in many clinical contexts that are encountered in the respiratory medicine department. We can predict the ABG values from the VBG values from regression equation. Though there was significant correlation, venous PO_2 cannot substitute arterial PO_2 as there was lack of agreement. Further study is suggested to validate VBG values in suspected respiratory failure patients.

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