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Comparison and Agreement between Venous and Arterial Blood Gas Values for pH, pCO_2, pO_2, Bicarbonate and Oxygen Saturation in Patients with Acute Respiratory Illnesses

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ABSTRACT
Arterial blood gas (ABG) analysis is routinely performed for sick patients but is fraught with complications, is painful, and is technically demanding. As there is a huge requirement of performing ABG analysis, an alternative to the arterial puncture would be quite helpful in this setting, and the current study was aimed to determine the extent of correlation of arterial and venous blood gas (VBG) analysis with a view to identifying whether the venous samples can be used as an alternative to arterial values in clinical management of patients presenting with various acute respiratory illness. This prospective observational study was conducted on 90 patients who presented with acute respiratory illness in in-patient Department of Medicine and Pulmonology, Mata Chanan Devi Hospital, after applying specific inclusion & exclusion criteria. Pregnant ladies, patients having age less than 20 years and those who were having respiratory symptoms due to non-respiratory causes were excluded from this study. Arterial sample was drawn via an arterial puncture into a heparinized syringe in all patients and at the same time, venous blood was also taken, without application of tourniquet via antecubital vein into another heparinized syringe. Venous and arterial blood samples were taken within 5-minutes of each other and in addition to this, the measurement of oxygen saturation (SpO2) was obtained from finger pulse oximeter. In order to access the agreement between values of two samples, the paired t-test and Pearson correlation coefficient was used. The mean age of the patient in the present study was 62.4 ± 14.75 years and gender distribution was 54 males and 36 females out of total 90 patients. After statistical evaluation, the present study shows minimal difference and good correlation between arterial and venous samples for the values of pH, bicarbonates, pCO2 ($r > 0.9$). Although the correlation of pO2 measurement was fair ($r = 0.615$) , but there was good correlation between values of finger pulse oximeter and arterial oxygen saturation($r > 0.9$). Thus, venous blood may be a useful alternative to arterial blood during blood gas analysis in the management of patients with acute respiratory illnesses. However, further large scale studies are needed to accurately assess whether VBG analysis can always replace ABG analysis.
Keywords: *Arterial blood gas analysis, venous blood gas analysis.*

Introduction

Arterial blood gas (ABG) analysis is routinely performed for sick patients but is fraught with complications, is painful, and is technically demanding. Respiratory diseases and conditions that affects lungs can be evaluated from this analysis. It tells us about the effectiveness of oxygen therapy, about the body's acid/base

balance, which can give important clues about lung and kidney functions and the body's general metabolic state. Blood gases is a measurement of how much oxygen and carbon dioxide is in your blood. It also determines the acidity (pH) of your blood. Usually, blood is taken from an artery. The blood may be collected from the radial artery in the wirst , the femoral artery in the groin, or the brachial artery in the arm. Small needle will be inserted through skin into the artery to get the sample. Anaesthesia may be applied to the site before the test begins. After taking the blood, pressure must be applied to the site for some minutes to stop the bleeding. The site should be watched for any signs of bleeding or circulation problems. Sample should be sent quickly for analysis[1,2].

Risk associated with ABG is little when done correctly. Veins and arteries vary in size from one patient to another. Risk associated with this test may include[3,4]-

Bleeding at puncture site
Bruising at the puncture site
Delayed bleeding at the puncture site
Fainting or feeling light-headed
Hematoma
Infection
Blood flow problems at puncture site(rare)

Normal Values[5]:

Partial pressure of oxygen: 75 – 100 mmHg
Partial pressure of carbon dioxide : 38 – 42 mmHg
Arterial blood pH : 7.38 – 7.42
Oxygen saturation : 94 – 100%
Bicarbonate : 22 – 28 meq/L

Note : meq/L= milliequivalents per litre ; mmHg = millimetres of mercury

A study conducted on patients with acute respiratory illness or potential ventilatory compromise by Kelly et al[6] in 2002, showed that venous pH is an acceptable substitute for arterial measurement but there is not sufficient agreement for venous pCO2 to be able to replace arterial pCO2 in the clinical evaluation of ventilatory function. Another study conducted by Malatesha G et al[7] in 2007 showed that venous blood gas analysis for pH, bicarbonates and pCO2 may be a reliable substitute for ABG analysis in the initial evaluation of an adult patient population presenting to the ED. Recently, studies have shown that values of acid–base balance measured in central or peripheral venous blood correlate well with those measured in arterial blood, at least for values of pH, bicarbonate, and carbon dioxide tension[8,9,10]. As per the study conducted by Koul, Khan et al[11] in 2011 on cardiopulmonary patients in high altitude of indian subcontinent (kashmir valley),venous measurement of pH,pCO2,pO2 and bicarbonates, and the digital oxygen saturation were highly correlated with their corresponding arterial measurements. Richard Treger et al[12] in 2010 conducted a study on agreement between central venous and arterial blood gas measurements in ICU patients and concluded that peripheral or central venous pH, pCO2 and bicarbonate can replace their arterial equivalents in many clinical contexts encountered in ICU. Middleton et al[13] , in their prospective study to determine ventilator or acid-base status by comparing pH in arterial and venous sample, founded that values were highly correlated (r= 0.92) with an average difference between the samples of 0.04 units. Shilpi Awasthi, Raka Rani, and Deepak Malviya[14] in their study concluded that venous blood may be a useful alternative to arterial blood during blood gas analysis obviating the need for arterial puncture in difficult clinical situation especially trauma patients, for initial emergency department assessment and early stages of resuscitation.

As there is a huge requirement of performing ABG analysis, an alternative to the arterial puncture would be quite helpful in this setting, and the current study is aimed to determine the extent of correlation of arterial and venous blood gas (VBG) analysis with a view to identifying whether the venous samples can be used as an alternative to arterial values in clinical management of patients presenting with various acute respiratory illness.

Objectives

1. To ascertain agreement between the arterial and peripheral venous measure-ment of pH, pCO_2, pO_2, and bicarbonate levels in sick patients with acute respiratory illnesses admitted in Mata Chanan Devi Hospital, New Delhi
2. To compare oxygen saturation in the arterial blood with finger pulse oximetry reading.

Material and Methods

Study Area: Mata Chanan Devi Hospital, New Delhi

Reasons for Doing the Study

As there is a huge requirement of performing ABG analysis, an alternative to the arterial puncture would be quite helpful in this setting, and the current study was aimed to determine the extent of correlation of arterial and venous blood gas (VBG) analysis with a view to identifying whether the venous samples can be used as an alternative to arterial values in clinical management of patients presenting with various acute respiratory illness.

Arterial blood gas (ABG) analysis is routinely performed for sick patients but is

- fraught with complications,
- is painful, and
- is technically demanding.

On the other hand, Venous Blood Gas(VBG) analysis has an advantage of

- being less painful,
- associated with less complications,
- technically easy and
- can be simultaneously obtained at the time of taking sample for other investigations.

Study Population

- IPD
- Males and Females
- Urban
- Adult

Sample Size and Sample Technique

Previously, many studies (Treger, Pirouz et al 2010; Koul, Khan et al 2011)[11,12] have obtained the correlation/agreement between venous and arterial blood gas values in terms of reading on pH, PCO2, Bicarbonates, PO2 etc. Considering the mean difference of 0.86 ± 2.15 (Koul, Khan et al, 2011)[11] in the bicarbonate levels between the two samples as reference, the minimum required sample size for this study with 5% level of significance and 95% power was obtained as 81 patients. Hence, in this study, 90 patients were enrolled.

Data Collection Tools and Techniques

PLACE: The study was conducted in in-patient Department of Medicine and Department of Pulmonology, Mata Chanan Devi Hospital, on carefully selected patients with acute respiratory illness after applying specific inclusion & exclusion criteria.

Time Frame: From June 2014 to June 2016

Type of Study: A prospective, observational study

Inclusion & Exclusion Criteria

Inclusion Criteria

- Above 20 years of age, irrespective of gender
- Confirmed cases of acute respiratory illnesses

All study subjects gave full informed consent for inclusion in study

Exclusion Criteria

- Inability to give informed consent
- Pregnancy
- Patients having respiratory symptoms due to non-respiratory causes

Investigations

Complete Hemogram, LFT, KFT, urine R/M, Chest X-Ray, ABG, VBG

Consent and Method

- Written informed consent was taken from the patient at the time of admission and purpose of study was explained.

- Arterial sample was drawn *via* an arterial puncture into a heparinized syringe in all patients.
-
- At the same time, venous blood was also taken, without application of tourniquet *via* antecubital vein into another heparinized syringe.
- Venous and arterial blood samples were taken within 5-minutes of each other.
- In addition, the measurement of oxygen saturation (SpO_2) was obtained from a finger pulse oximeter.
- It compared pH, pCO_2, pO_2 and bicarbonates on arterial and venous samples taken within 5 minutes of each other. Oxygen saturation in arterial blood (SaO_2) was compared with finger pulse oximeter reading.

Data Management

Data was collected and stored with following software -:

- Microsoft Word 2007
- Microsoft Office Excel 2007

Data Analysis

In order to assess the agreement between the values of the two sample, we used the paired t-test. Also the correlation was evaluated using Pearson correlation coefficient. A p-value <0.05 was considered statistically significant. Statistical Package for Social Sciences (SPSS) version 15.0 was used for analysis.

Salient findings of the Study

- The present study was carried out on 90 patients admitted with acute respiratory illness in the Departments of Medicine and Pulmonology of Mata Chanan Devi Hospital, New Delhi.
- The mean age of the patient in the present study was 62.4 ± 14.75 years
- Gender distribution was 54 males and 36 females out of 90 patients.
- Mean ± SD of arterial and venous pH was 7.26 ± 0.11 and 7.23 ± 0.11 respectively with Pearson correlation coefficient r= 0.982 and p<0.001, showing significant correlation even at low pH in sick patients.
- Mean ± SD of pCO_2 in arterial and venous blood was 65.99 ± 17.57 and 71.73 ± 17.92 mmHg respectively with Pearson correlation coefficient r= 0.992 and p<0.001, showing significant correlation between arterial and venous samples even at high pCO_2 levels.
- Mean ± SD of pO_2 in arterial and venous blood was 64.58 ± 4.25 and 37.74 ± 4.82 mmHg respectively with Pearson correlation coefficient r=0.615 and p<0.001. Although there is significant statistical correlation between venous and arterial pO_2 values, but the difference is large for a clinical acceptance.
- Mean ± SD of bicarbonate in arterial and venous blood was 26.97 ± 5.17 and 27.64 ± 5.09 mmol/l respectively with Pearson correlation coefficient r= 0.991 and p<0.001, showing good correlation with clinically acceptable difference.
- Mean ± SD of oxygen saturation in arterial blood and finger pulse oximeter reading was 87.81 ± 3.60 and 89.16 ± 3.14 respectively with Pearson correlation coefficient r=0.961 and p<0.001, showing significant statistical correlation.

Demographic Profile of the Study Group

Age Distribution

Table 1 – The distribution of age of subjects in study group

Age(years)	Frequency	Percent
30-40 Yrs	9	10
41-50 Yrs	11	12.2
51-60 Yrs	14	15.6
61-70 Yrs	28	31.1
71-80 Yrs	19	21.1
81-90 Yrs	9	10
Total	90	100

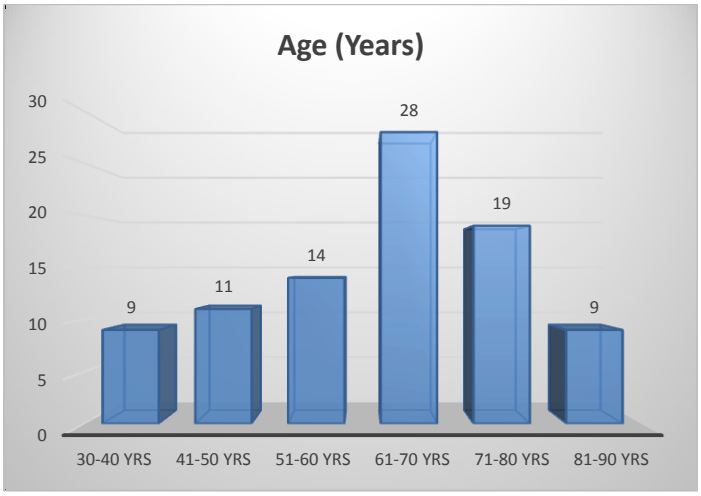

Figure 1- Distribution of patients in different Age Groups

Table 1 and Figure 1 shows the distribution of age of subjects in study group. Majority (28 out of 90) of the subjects were in the age group 61-70 yrs. The mean age of the subjects in the study group was 62.4 ± 14.75 years.

Sex Distribution in the Study Group

Table 2 – Sex Distribution

Sex	Frequency	Percent
Male	54	60
Female	36	40
Total	90	100

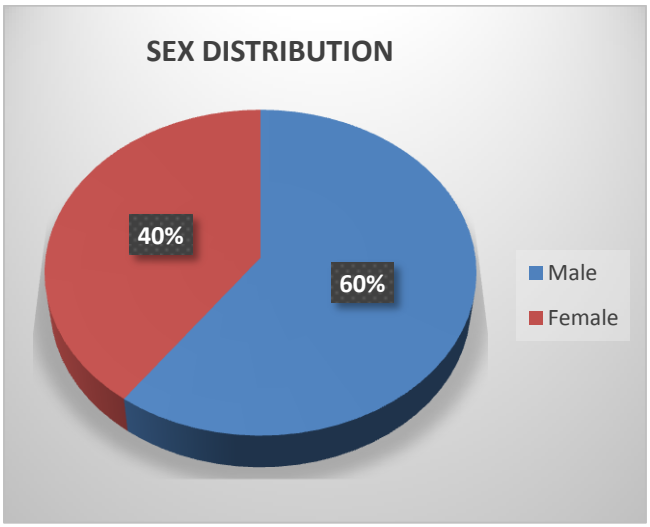

Figure 2 – Sex Distributionin the study group

Table 2 and Figure 2 shows the sex distribution in the study group. In the present study , there were 56 male and 34 female patients. The male to female ratio was 3:2.

Disease Distribution among Subjects

Table 3- Disease Distribution

Disease Involved	Number Of Cases
AECOPD	57
CAP	23
POST-TUBERCULAR FIBROSIS	06
ILD	04
TOTAL	90

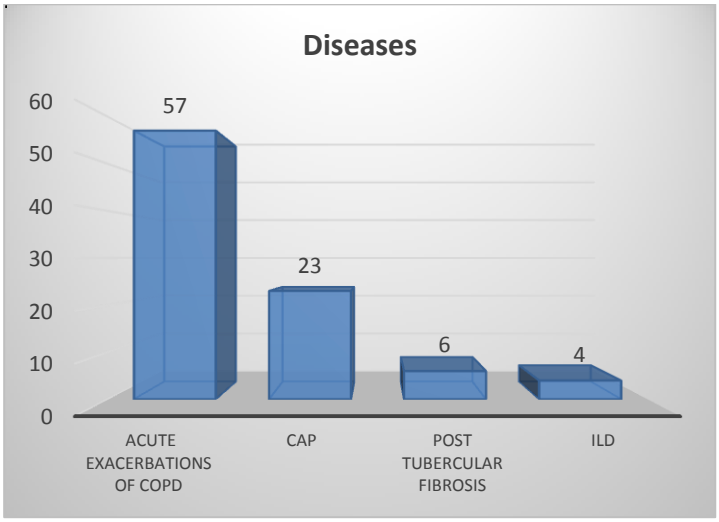

Figure 3- Disease Distribution

Table 3 and Figure 3 shows disease distribution among subjects. In the present study, maximum number of patients were of AECOPD that accounted for 57 patients out of total 90 patients.

Comparison of pH in Arterial and Venous Samples

Table 4 - Comparison of Mean ± SD of pH in Arterial and Venous Samples

pH	Mean	N	Std. Deviation	Std. Error Mean	t-value	p-value
ABG	7.26	90	0.11	0.01	17.93	<0.001
VBG	7.23	90	0.11	0.01		

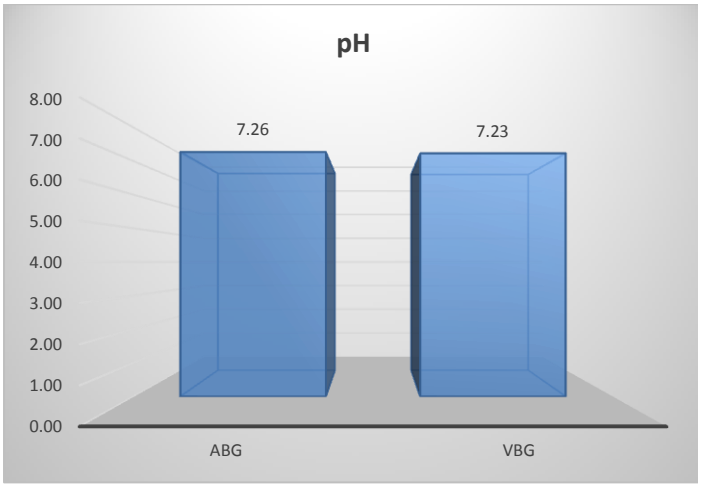

Figure 4 - Comparison of Mean of pH in ABG and VBG

Table 4 and Figure 4 shows the comparison of mean of pH in ABG and VBG. In the present study, mean ± SD of arterial and venous pH was 7.26 ± 0.11 and 7.23 ± 0.11 respectively with Pearson correlation coefficient r= 0.982 and p<0.001, showing significant correlation between the two values.

Comparison of pO_2 in Arterial and Venous Samples

Table 5 – Comparison of Mean ± SD of pO_2 in ABG and VBG

	Mean	N	Std. Deviation	Std. Error Mean	t-value	p-value
pO_2 in mmHg(ABG)	64.58	90	4.25	0.45	63.41	<0.001
pO_2 in mmHg(VBG)	37.74	90	4.82	0.51		

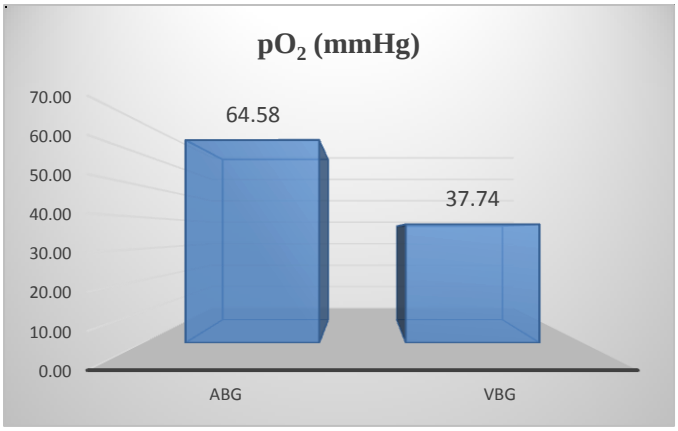

Figure 5-Comparison of Mean of pO_2 in ABG and VBG

Table 5 and Figure 5 shows mean of pO_2 in ABG and VBG. In the present study, the mean ± SD of pO_2 in arterial and venous blood was 64.58 ± 4.25 and 37.74 ± 4.82 mmHg respectively with Pearson correlation coefficient r=0.615 and p<0.001, showing significant correlation between the two values.

Comparison of pCO_2 in Arterial and Venous Samples

Table 6 – Comparison of Mean ± SD of pCO_2 in ABG and VBG

	Mean	N	Std. Deviation	Std. Error Mean	t-value	p-value
pCO_2 in mm Hg(ABG)	65.99	90	17.57	1.85	24.05	<0.001
pCO_2 in mm Hg(VBG)	71.73	90	17.92	1.89		

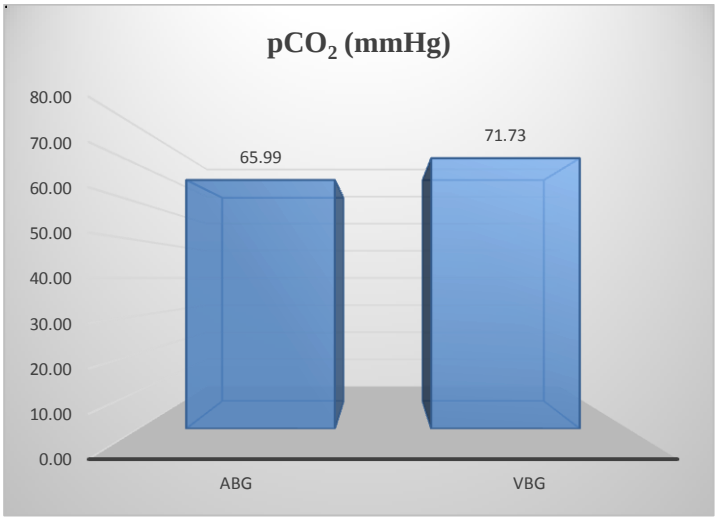

Figure 6 – Comparison of Mean of pCO_2 in ABG and VBG

Table 6 and Figure 6 shows the comparison of mean of pCO_2 in ABG and VBG. In the present study, the mean ± SD of pCO_2 in arterial and venous blood was 65.99 ± 17.57 and 71.73 ± 17.92 mmHg respectively with Pearson correlation coefficient r= 0.992 and p<0.001, showing significant correlation between the two values.

Comparison of Bicarbonatein Arterial and Venous Samples

Table 7- Comparison of Mean ± SD of bicarbonatein ABG and VBG

	Mean	N	Std. Deviation	Std. Error Mean	t-value	p-value
HCO_3^- in mmol/L (ABG)	26.97	90	5.17	0.54	9.30	<0.001
HCO_3^- in mmol/L (VBG)	27.64	90	5.09	0.54		

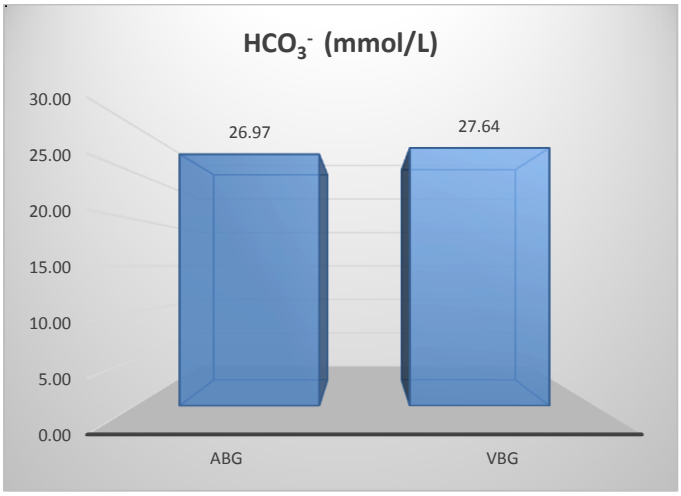

Figure 7 – Comparison of Mean of bicarbonate in ABG and VBG

Table 7 and figure 7 shows mean of bicarbonates in ABG and VBG. In the present study, mean ± SD of bicarbonate in arterial and venous blood was 26.97 ± 5.17 and 27.64 ±5.09 mmol/l respectively with Pearson correlation coefficient r= 0.991 and p<0.001, showing significant correlation between the two values.

Comparison of Oxygen Saturation in Arterial Sample and Pulse Oximeter

Table 8- Comparison of Mean ± SD of SaO_2in ABG and SpO_2 in Pulse Oximeter

	Mean	N	Std. Deviation	Std. Error Mean	t-value	p-value
SaO_2 in ABG	87.81	90	3.60	0.38	12.14	<0.001
SpO_2 in PULSE OXIMETER	89.16	90	3.14	0.33		

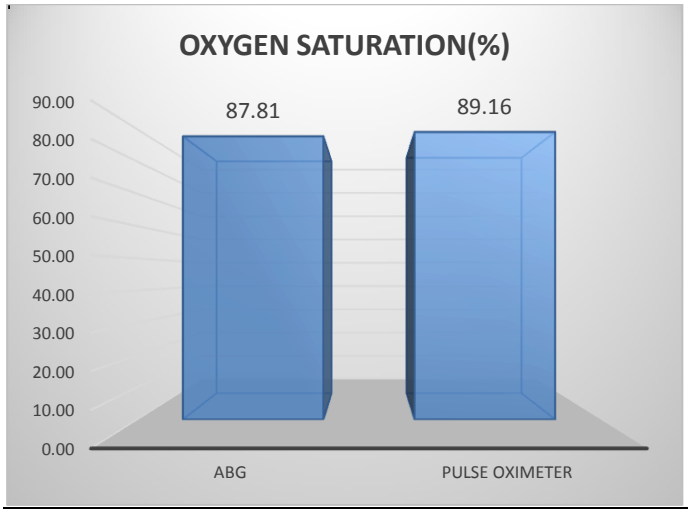

Figure 8 – Comparison of Mean of oxygen saturationin ABG and Pulse Oximeter

Table 8 and figure 8 shows mean of oxygen saturation in ABG and Pulse Oximeter. In the present study, the mean ± SD of oxygen saturation in arterial blood and finger pulse oximeter reading was 87.81 ± 3.60 and 89.16 ± 3.14 respectively with Pearson correlation coefficient r=0.961 and p<0.001, showing sifnificant correlation between the two values.

Discussion

Middleton et al[13] , in their prospective study to determine ventilator or acid-base status by comparing pH in arterial and venous sample, founded that values were highly correlated (r= 0.92) with an average difference between the samples of 0.04 units. Based on this, they concluded that venous estimation is an acceptable alternative to arterial values. Similarly, in the present study, good correlation between arterial and venous pH was found.

Shilpi Awasthi et al[14] also compared peripheral venous blood gas analysis and arterial blood gas analysis and founded good correlation.

Koul et al[11] did prospective study of patients in Kashmir valley to determine the extent of correlation between arterial and venous gas analysis in cardio-pulmonary patients. Arterial and venous pH, pCO_2, pO_2 and bicarbonates as well as SaO_2 (oxygen saturation in arterial blood) and SpO_2 (finger pulse oximeter) values were found to

be correlated significantly with Pearson correlation coefficient r= 0.88 and p<0.001 for pH, r= 0.92 and p<0.0001 for pCO_2 , r= 0.32 and p= 0.0012 for bicarbonate , r=0.45 and p<0.0001 for pO_2 and finally r= 0.59 and p<0.001 for oxygen saturation. As was found by the above study, present study also showed significant correlation between arterial and venous values with Pearson correlation coefficient r= 0.982 and P<0.001 for pH , r= 0.992 and P<0.001 for pCO_2 ,r= 0.991 and P<0.001 for bicarbonate , r=0.615 and P<0.001 for pO_2 and finally r= 0.961 and P<0.001 for oxygen saturation.

Conclusion

Venous blood gas analysis correlates well with arterial blood gas analysis especially for values of pH, pCO_2 and bicarbonates level with a high degree of agreement and clinically acceptable difference.

There was a significant correlation between the arterial and venous values of pO_2 level, but the difference between the arterial and venous values was not clinically acceptable enough to recommend the use of venous pO_2, in place of arterial pO_2 , in clinical setup. However, there was high correlation between oxygen saturation in arterial blood (SaO_2) and oxygen saturation in pulse oximetry (SpO_2) with excellent agreement and clinically acceptable difference. Further studies are needed to assess more accurately the correlation between venous and arterial blood gas analysis.

Recommendations

- Peripheral venous blood analysis can fairly replace arterial blood gas analysis for the values of pH, pCO_2 and bicarbonate.
- Moreover, ABG analysis is fraught with complications, is painful, and is technically demanding. On the other hand, Venous Blood Gas(VBG) analysis has an advantage of being less painful, associated with less complications, technically easy and can be simultaneously obtained at the time of taking sample for other investigations.
- This is particularly useful in Indian setup, where there are busy emergencies and lack of sufficient resources.
- Although there is significant statistical correlation between venous and arterial pO_2 values, but the difference is large for a clinical acceptance. However, the SpO_2 and SaO_2 values have shown good correlation with clinically acceptable difference. Hence, if venous pH is combined with routine finger pulse oximetry, the ABG analysis might be minimized to a great degree in acute respiratory illness patients. Further large scale studies are needed to accurately assess whether VBG analysis can always replace ABG analysis.

Bibliography

1. Murray and Nadel's Textbook of Respiratory Medicine. 5th ed. Philadelphia Pa : Saunders Elsevier; 2010: chap 7.
2. Cecil medicine. 24th ed. Philadelphia , Pa : Saunders Elsevier; 2011: chap 120
3. Mortensen J. Clinical sequelae from arterial needle puncture, cannulation, and incision. Circulation.1967;35:1118–23.
4. Criscuolo C, Nipper G, Buchalter S. Reflex sympathetic dystrophy following arterial blood gas sampling in the Intensive Care setting. Chest. 1995;108:578–80.
5. Effros RM, Swenson ER. Acid-base balance. In: Mason RJ, Broaddus CV, Martin TR, et al. *Murray & Nadel's Textbook of Respiratory Medicine*. 5th ed. Philadelphia, PA: Saunders Elsevier; 2010:chap 7.
6. Kelly AM, Kyle E, McAlpine R. Venous pCO_2 and pH can be used to screen for significant hypercarbia in emergency patients with acute respiratory disease. J Emerg Med. 2002;22:15–9.

7. Malatesha G, Singh NK, Bharija A, Rehani B, Goel A. Comparison of arterial and venous pH, bicarbonate, pCO_2 and pO_2 in initial emergency department assessment. Emerg Med J.2007;24:569–71.
8. Toftegaard M, Rees SE, Andreassen S. Correlation between acid-base parameters measured in arterial blood and venous blood sampled peripherally, from vena cavae superior, and from the pulmonary artery. Eur J Emerg Med. 2008;15:86–91.
9. Kelly AM, McAlpine R, Kyle E. Venous pH can safely replace arterial pH in the initial evaluation of patients in the emergency department. Emerg Med J. 2001;18:340–2.
10. Rees SE, Hansen A, Toftegaard M, Pedersen J, Kristiensen SR, Harving H. Converting venous acid-base and oxygen status to arterial in patients with lung disease. Eur Respir J. 2009;33:1141–7.
11. Koul PA, Khan UH, Wani AA, Eachkoti R, et al.Comparison and agreement between venous and arterial gas analysis in cardiopulmonary patients in kashmir valley of indian subcontinent.Ann thorac med 2011;6:33-7.
12. Richard Treger, Shahrjar Pirouz, Nader Kamangar and Dalila Corry. Agreement between Central Venous and Arterial Blood Gas Measurements in the Intensive Care Unit. Clin J Am Soc Nephrol. 2010 Mar; 5(3): 390–394.
13. Middleton P, Kelly AM, Brown J, Robertson M. Agreement between arterial and central venous values for pH, bicarbonate, base excess, and lactate. Emerg Med J. 2006;23:622–4.
14. Awasthi S, Rani R, Malviya D. Peripheral venous blood gas analysis: An alternative to arterial blood gas analysis for initial assessment and resuscitation in emergency and intensive care unit patients. Anesth Essays Res. 2013; 7:355–8.

Abbreviations

ABG: Arterial Blood Gas
AECOPD: Acute Exacerbations of Chronic Obstructive Pulmonary Disease
CAP: Community Aquired Pneumonia
ILD: Interstitial Lung Disease
HCO_3: Bicarbonate ion
pCO_2: Partial pressure of carbon dioxide in blood
pO_2: Partial pressure of oxygen in blood
ΔpH: Difference between arterial pH and venous pH
SaO_2: Oxygen saturation in arterial blood
SpO_2: Oxygen saturation in pulse oximeter
VBG: Venous Blood Gas