Comparison of arterial and venous blood gases analysis in patients with exacerbation of chronic obstructive pulmonary disease

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ABSTRACT

Objective: To investigate whether venous blood gases (VBG) test can be replace by an arterial blood gases (ABG) in exacerbation of chronic obstructive pulmonary disease (COPD).

Methods: From October 2005 to March 2006, at the Emergency Room of Kashan Beheshti Hospital, the data of 107 patients with exacerbation of COPD were assessed. Arterial blood gases and VBG samples were obtained simultaneously, and indexes of pH, carbon dioxide partial pressure (PCO_2), bicarbonate (HCO_3), oxygen partial pressure (PO_2) and Oxygen (O_2) saturation level were analyzed.

Results: The mean ± SD of indexes in ABG and VBG samples were as follows: pH = 7.37 ± 0.47 versus 7.34 ± 0.047; PCO_2 = 53.88 ± 7.63 mm Hg versus 59.55 ± 8.96 mm Hg, HCO_3= 30.66 ± 4.49 mEq/L versus 31.94 ± 4.39 mEq/L; PO_2 = 55.37 ±11.19 mm Hg versus 43.08 ± 10.54 mm Hg. The average difference between indexes in ABG and VBG samples were as follows: pH = 0.0241 ± 0.004, $p<0.001$, r = 0.864; PCO_2 = 5.673 ± 1.126 mm Hg, $p<0.001$, r = 0.761; HCO_3 = 1.279 ± 0.604 mEq/L, $p<0.001$, r = 0.749; and PO_2 = 12.294 ± 2.115 mm Hg, $p<0.001$, r = 0.702.

Conclusion: Venous blood gases, especially pH and PCO_2 levels have relatively good correlation with ABG values. In view of the fact that, this correlation is not close, VBG cannot be substitute for ABG in exacerbation of COPD.

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Analysis of arterial blood gases (ABG) has an important role in evaluating advanced form of chronic obstructive pulmonary disease (COPD) and its complication. In COPD patients, when saturation of oxygen with pulse oximeter (SPO_2) is lower than 92%, ABG analysis is recommended.[1] Despite its high efficacy in evaluating patient's response to treatment regimens, ABG test has some complications. The most common complications associated with arterial puncture are pain, arterial injury, infection, thrombosis with distal digits ischemia, hemorrhage, and aneurysm formation.[2] Limited studies have been carried out regarding substituting VBG analysis for ABG analysis in assessment of acid-base status and ventilatory function.[3-6] In a study performed by Kelly et al,[3] venous pH estimation shows a high degree of correlation (r=0.92) with the arterial value. Another study compared pH and carbon dioxide partial pressure (PCO_2), levels obtained from arterial and venous blood samples demonstrated significant correlation.[7] Gennis et al,[8] reported that high correlation for pH, PCO_2, and bicarbonate (HCO_3), but the accuracy of predicting arterial values are limited, and they concluded that venous blood sampling cannot be used for routine assessment of acid-base status. In patients with diabetic ketoacidosis, pH and PCO_2 levels obtained from VBG have good correlation in comparison with ABG values.[9] In Elborn et al,[4] study conducted on COPD patients, they observed no significant difference between the arterial and venous CO_2 tensions, and the 2 were closely correlated. In Kelly et al,[6] study that performed in patients with acute respiratory disease showed that venous pH was an acceptable substitute for arterial samples but there is no sufficient agreement for venous PCO_2 to be replaced by arterial PCO_2 in the clinical evaluation of ventilatory function. The aim

of this study is to determine the correlation between arterial and venous blood gases analysis in exacerbation of COPD, and also to show whether VBG values can be substituted for ABG in clinical management of the patients.

Methods. The present study was conducted on patients with advanced form of COPD attended to the Emergency Room of Kashan Shahid Beheshti Hospital, between October 2005 and March 2006. The inclusion criteria were patients suffered from COPD exacerbation associated with hypercapnia, and with a $PaCO_2$ level more than 45 mm Hg. Patients were excluded if they had concurrent disease such as malignancies, gastrointestinal or kidney abnormalities, diabetes mellitus, or underwent diuretic therapy. Arterial and venous blood samples were collected simultaneously with a minimum delay between the takings of samples. Spirometry was performed in the same day using a spirometer (Fukuda ST 95 Japan), and the mean±SD of forced volume capacity (FVC), and forced expiratory volume-1 (FEV1) were measured. The mean ± SD pH, PCO_2, HCO_3 and oxygen partial pressure (PO_2) values in arterial and venous samples were determined. Arterial and venous blood samples after obtaining with a heparinized syringe were labeled and sent to the laboratory in ice. Within less than 15 minutes, the 2 samples were analyzed using AVL 550 GRAZ blood gas analysis machine. The samples were categorized into 2 groups based on venous oxygen saturation level: ≥70%, and <70%. Venous-to-arterial PCO_2 gradient values were determined based on the values: ≤5 mm Hg or >5 mm Hg. We compared venous-to-arterial gradient values with venous oxygen saturation level using Chi-squared comparison test. The comparison between ABG and VBG values such as pH, PCO_2, HCO_3 and PO_2 was carried out by Pearson methods. The mean arterial and venous samples values were compared using Student's t-test. P-value <0.05 was considered statistically significant. Data were analyzed using the Statistical Package for Social Science Version 11.1.

Results. The study was carried out on 107 patients with advanced COPD (79 males, 28 females, with an average age 68 ± 14 years). Demographic characteristic is demonstrated in **Table 1**. Arterial and venous blood gases values are shown in **Table 2**. In **Table 3**, mean± SD of venous-to-arterial gradient, correlation coefficient, and 95% confidence interval between arterial and venous blood gas values are presented. There were significant differences between ABG and VBG values (p<0.001). As shown, there were better correlation regarding pH value than other values in ABG and VBG samples (p<0.001, r=0.864). **Table 4** shows distribution prevalence rate of venous-to-arterial PCO_2 gradient based on venous O_2 saturation level in patients with advanced COPD. We observed that when venous oxygen saturation level was ≥70% the number of patients with venous-to-arterial PCO_2 gradient ≤5 mm Hg were more than the number of patients with venous oxygen saturation <70% (45.8% versus 7.5%).

Discussion. The study demonstrated that there was a good correlation regarding pH values in ABG samples in patients suffering from advanced form of COPD associated with PCO_2 retention (r=0.864, p<0.001). But regarding other factors such as PCO_2, HCO_3 and PO_2, although there was a prominent association between them (p<0.001), but the existed correlation is not close and excellent. In COPD patients, ABG analysis is a standard routine test for investigation of acid-base imbalance and ventilatory status. Arterial blood gases is an invasive test being painful and having

Table 1 - Demographic data of the patients with advanced chronic obstructive pulmonary disease.

Characteristics	Values
Gender	
Male	79 (19.8)
Female	28 (26.2)
Age (years)	68 ± 14
Forced expiratory volume in one second (FEV1)	
Liter	0.78 ± 0.19
Predicted (%)	33.16 ± 6.21
Forced vital capacity (FVC)	
Liter	1.36 ± 0.28
Predicted (%)	44.11 ± 5.09
FEV1/FVC (%)	56.51 ± 10.41

Data are presented as mean ± SD

Table 2 - Arterial and venous gases analysis in patients with advanced chronic obstructive pulmonary disease.

Variables	Arterial blood gases	Venous blood gases	*P* value
pH	7.37 ± 0.047	7.34 ± 0.047	<0.001
PCO_2	53.88 ± 7.63	59.55 ± 8.96	<0.001
HCO_3	30.66 ± 4.49	31.94 ± 4.39	<0.001
PO_2	55.37 ± 11.19	43.08 ± 10.54	<0.001
O_2 saturation	85.57 ± 7.03	72.81 ± 13.70	<0.001

PCO_2 - carbon dioxide partial pressure, HCO_3 - bicarbonate, PO_2 - oxygen partial pressure, O_2 - Oxygen

Table 3 - The correlation coefficient in arterial and venous samples regarding pH, PCO_2, HCO_3, PO_2, and O_2 saturation in patients with advanced chronic obstructive pulmonary disease.

Variables	Venous-arterial gradient (mean± SD)	Correlation coefficient	95% confidence interval	P value
pH	0.0241 ± 0.004	0.864	0.0194 - 0.0289	<0.001
PCO_2	5.673 ± 1.126	0.761	4.548 - 6.799	<0.001
HCO_3	1.279 ±0.604	0.749	0.676 - 1.882	<0.001
PO_2	12.294 ± 2.115	0.702	10.680 - 13.908	<0.001
O_2 saturation	12.755 ± 2.152	0.577	10.603 - 14.907	<0.001

PCO_2 - carbon dioxide partial pressure, HCO_3 - bicarbonate, PO_2 - oxygen partial pressure, O_2 - Oxygen

Table 4 - Distribution prevalence rate of venous-arterial carbon dioxide partial pressure gradient based on venous oxygen saturation level in patients with advanced form of chronic obstructive pulmonary disease.

Levels	>5 mm Hg	≤5 mm Hg	Total
Venous-arterial O_2 gradient	23 (21.5)	49(45.8)	**72 (67.3)**
Venous-arterial O_2 gradient	27 (25.2)	8 (7.5)	**35 (32.7)**
Total	**50 (46.7)**	**57 (53.3)**	**107 (100)**

Data are expressed as number and percentage (%).

some complications such as infection, local hematoma, vascular injury, thrombosis and ischemic injury to the digits.[2] Therefore, in order to decrease its complication, other alternatives as VBG analysis, pulse oximetry, end-tidal CO_2, transcutaneous monitoring of oxygen and CO_2 seemed to be useful.[2] If a blood gas value determined by venous could be used to show patient's acid-base status and guide their management with the same accuracy as arterial sampling, this would be preferable because of ease of collection blood sample. In this regard, there have been reported various studies in children and adults in order to investigate the accuracy and efficacy of VBG analysis versus ABG.[3,6,10-14] In study carried out by Kelly et al[3] on 196 patients with acute respiratory disorder and 50 patients with the suspected metabolic derangement, the venous pH estimation showed a high degree of correlation and agreement with the arterial value (r=0.92). In the present study, this correlation was 0.864 that is not excellent (r<0.90). In another study that was conducted on 44 episodes of diabetic ketoacidosis, the mean difference between arterial and venous pH values was 0.03 that was highly correlated (r=0.9689).[9] In a study by Gokel et al that was carried out in chronic uremia and diabetic ketoacidosis, the correlation between arterial and venous pH was 0.979 and 0.989 respectively; but in healthy control subjects the correlation was 0.595.[14] In Gokel et al study, it was 0.05 ± 0.01 and 0.04 ± 0.02 in diabetic ketoacidosis and uremic acidotic respectively.[14] In the current study, it was 0.241 ± 0.004. In another study that was conducted on pediatrics, the mean difference of pH value in ABG and VBG samples was 0.05 ± 0.02, and the mean difference of PCO_2 value was 8 ± 4 mm Hg.[11] In McBride et al study on infants and children after cardiothoracic surgery, the mean difference of pH and PCO_2 values in ABG and VBG were 0.04 ± 0.02 and 8 ± 4 mm Hg.[11] They concluded that VBG values did not provide a clinically useful estimate of ABG values following cardiothoracic surgery.[11] Recently, Kelly[12] summarized some data on validity of VBG sampling in ketoacidosis; they found that venous and arterial pH had sufficient agreement as to be clinically interchangeable.[12] It should be mentioned that more studies conducted on the substitution of VBG values for ABG ones have been carried out on pediatric patients. In one study that was carried out on pediatric intensive care unit, there was a significant correlation in pH, PCO_2, and HCO_3 among ABG and VBG values.[10] Correlation in PO_2 was also significant, but less so. Limited studies have been conducted regarding the substitution of VBG values for ABG in COPD patients.[6] In Kelly et al study on 196 patients with acute respiratory disease; 56 (29%) had significant hypercapnia, for pH there was a good agreement with venous samples, but there was no sufficient agreement for venous PCO_2 to be replace by arterial PCO_2 in the clinical evaluation of ventilatory function.[6] In the study by Rang et al, carried out on 218 patients with respiratory and metabolic illness, the correlation coefficient of pH, PCO_2 and HCO_3 values in arterial and venous samples were 0.913, 0.921, and 0.953 respectively.[5] The mean differences of pH, PCO_2, and HCO_3 between arterial and venous samples were: 0.036, 6 mm Hg, and 1.5 mEq/L respectively.[5]

In conclusion, VBG analysis does not have an excellent correlation in comparison with ABG analysis ($r<0.9$). The results show that VBG analysis cannot be substituted for ABG for evaluating ventilatory function and acid-base imbalance in patients with advanced form of COPD. Moreover, in the case of high venous oxygen saturation (≥70%), the prevalence rate of venous-arterial PCO_2 ≤5 mm Hg would increase.

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