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Can venous blood gas be used instead of arterial blood gas in emergency department?

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Abstract

Objective: In our study, we aimed to evaluate the usability of venous blood gas (VBG) in substitution for arterial blood gas (ABG).

Methods: In this study, 110 patients with respiratory complaints, who were brought intubated were evaluated prospectively. Arterial and venous blood gases were taken simultaneously shortly before the initiation of oxygen therapy in the emergency department. PH, pO2, pCO2, SaO2, HCO3, lactate (Lac) and BEecf values were recorded.

Results: Of the 110 patients included in the study, 75 were male (68.2%), 35 were female (31.8%), and they had a mean age of 53.7 ± 23.1 years. A strong positive correlation between PH, PCO2, HCO3-, BEecf, Lac values (p=0.001) and positive correlation between PO2 and SaO2 values (p= 0.002) were detected.

Conclusion: We can conclude that venous blood gas be used in substitution for arterial blood gas in patients who are presented to emergency service and it may reduce the need for arterial blood gas sampling.
Keywords: Arterial Blood Gas, Venous Blood Gas, Emergency Department

INTRODUCTION

Arterial blood gas (ABG) analysis is a commonly used laboratory method for the diagnosis, treatment and follow-up of respiratory and metabolic diseases, showing the acid base condition and giving useful findings for the clinical evaluation. Arterial blood gas analysis, which is frequently used for this purpose, is the gold standard. However arterial blood sampling is a painful method that causes vascular complications and poses a risk to health personnel in terms of contagious infections. Acquisition of ABG is a very difficult method due to disruption of patient comfort, pain, hematoma, embolism, ischemia and interventional practice.

Obtaining venous blood gas (VBG) sample is much easier than obtaining arterial blood gas sample and can also work concurrently with the blood sample taken for other laboratory studies. Therefore, the use of a venous blood gas sampling can prevent time loss caused by the arterial blood gas sampling and the risk of complications that may occur in the arterial puncture (1,2).

The ease of operation, practicality, speed and patient comfort are crucial in crowded and busy emergency services. The sooner the whole process is done, the sooner the diagnosis and conclusion can be made.

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In this work we have done, we aimed to evaluate the usability of venous blood gas in substitution for arterial blood gas because of the difficulty and risks of arterial blood sampling.

METHODS

The study included patients who were admitted to the Emergency Department as intubated and in need of intensive care, and congestive heart failure patients with respiratory distress. The research was conducted in an emergency department of a medium sized University Research Hospital, and 300 patients on average are admitted to our Emergency Department, daily. During the research period, 110 patients who were admitted to the Research Hospital of Hatay Mustafa Kemal University with respiratory complaints and with a poor general condition. They were evaluated prospectively in our study after obtaining the consent of the patients or their relatives. Arterial and venous blood gases were taken simultaneously (5 minutes at the latest) shortly before initiation of the oxygen therapy in the Emergency Department. First of all, Radial artery was used for arterial blood gas. Secondly, Femoral artery was preferred when blood could not have been taken from the radial artery and peripheral venules were used for venous blood gas. The blood samples were taken by the research assistants of the Emergency department on duty at the time of patient's admission. They were collected using a 2 ml blood gas injector with hypodermic needle containing 80 IU dry lithium heparin (Berika brand, Turkey). Without delay, samples were transferred to the biochemistry laboratory of the Research Hospital and analyzed there with GEM Premier 3000 analyzer (India).

Statistical Analysis

PH, pO_2, pCO_2, SaO_2, HCO_3, Lactate and BE_{ecf} values of blood gases taken for the study were recorded. Averages and safety intervals of arterial and venous variables were determined. The relationship between their values was determined and an equation was formulated to find arterial values from venous values by linear regression analysis.

Whether the data had normal distribution was analyzed using the Shapiro-Wilk test. The descriptive statistics for the blood gas parameters such as PH, pO_2, pCO_2, SaO_2, HCO_3, Lactate and BE_{ecf} were expressed as mean, minimum, maximum, and standard deviation The correlation between these variables were analyzed using Pearson's Correlation test, and correlation coefficient was calculated for them. Scatterplot method was used in graphic drawings. The statistical analysis was performed using the SPSS Statistics Software v21 and $p<0.05$ were considered as statistically significant.

Table 1. Blood gas values of patients

Blood gas	Arterial Blood Gas			Venous Blood Gas		
	Min	Max	Mean±SD	Min	Max	Mean±SD
SaO2	51	100	94.2±7.2	4	100	50.6±25.4
pO2	37	458	110.1±64.3	6	181	37.0±25.2
pH	6.80	7.54	7.33±0.14	6.80	7.56	7.27±0.15
pCO2	14	66	36.2±10.6	21	93	48.0±14.9
Lac	0.4	15.0	3.0±3.1	0.5	15.0	3.2±3.1
HCO3	6.4	37.3	19.9±5.8	6.0	40.5	22.7±6.5
BEecf	-24.1	13.5	-5.6±7.1	-26.3	16.7	-3.6±8.0

RESULTS

Of the 110 patients included in the study, 68.2% (n = 75) were male and 31.8% (n = 35) were female. The mean age was 53.7 ± 23.1 (4-92). At the time of admission, 65.5% (n = 72) had congestive heart failure (CHF) with respiratory distress, and 34.5% (n = 38) had poor overall condition, were unconscious and intubated by 112 ambulance crew. The blood gas values of the patients are shown in Table 1.

When the correlation values of arterial and venous blood gases are examined; mild positive correlation, (respectively r=0.395 and r=0.294) between arterial and venous SaO_2 and pO_2 values were detected. There was a strong correlation between the other parameters (Table 2). The strongest correlation was between HCO_3 values (Figure 1).

Table 2. Correlation values of arterial and venous blood gases

Parameter	r*	p
HCO_3	**0.915**	**0.001**
pH	**0.914**	**0.001**
Lac	0.909	0.001
BE_{ecf}	0.875	0.001
pCO_2	0.666	0.001
SaO_2	0.395	0.001
POI_2	0.294	0.002

* Pearson Correlation analysis, r: Pearson Correlation coefficient, p < .005

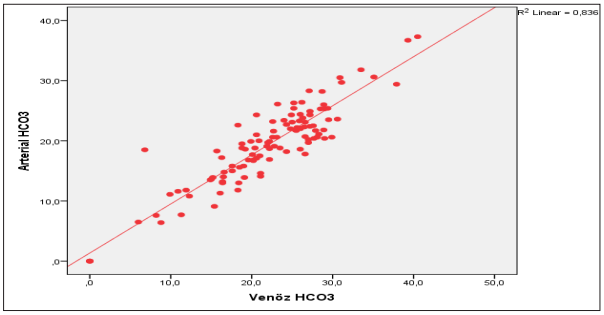

Figure 1. Correlation and linear regression line between arterial and venous HCO3

DISCUSSION

In a study conducted by Zahn and Weil to investigate the correlation between arterial and venous blood samples; it has been reported that there is an relation between arterial and venous PH values, and central venous blood samples could be used instead of arterial blood samples (4). Another study by Moore and Good, compared arterial and venous PH values in patients with hemorrhagic shock and hypothermia and reported that venous PH was a highly sensitive marker for assessing arterial PH (5).

Brandenburg and Dire investigated the effects of arterial blood gas results on diagnosis, treatment and follow-up of patients suspected of diabetic ketoacidosis. Correlations between arterial and venous PH, HCO_3^- values were calculated and they stated that the venous blood sample could be used easily if the PH value had to be known so that the patients in the emergency room could be evaluated (6).

Hale and Natrass, in the study they conducted on the cases with diabetic ketoacidosis, compared PH and PCO_2 values in arterial and venous blood gases and reported that venous blood samples could be used instead of arterial blood samples to assess the acid-base status in these cases (7). Although there were mostly studies comparing arterial and venous blood samples to evaluate metabolic acidosis in the literature; in 2001, Kelly et al. compared arterial and venous pH values in 196 patients with acute respiratory failure. They have stated that venous PH is an acceptable data to calculate arterial PH and thus may reduce complications that may arise, in terms of both patient and health personnel while taking arterial blood gas (3).

Zetos et al. evaluated the correlation between arterial and venous PH values in a study of 103 patients who referred to the emergency department of the Chest Diseases hospital with acute respiratory failure and they reported that venous PH could be used instead of arterial PH (8).

There are a lot of studies comparing direct arterial and venous PCO_2 values in the literature, and in these studies strong correlation between arterial and venous PCO_2 values were detected. It has been stated that the correlation found in these studies is not surprising, and this correlation is an expected finding because the arterial and venous PCO_2 values are part of the physiological system (9,10).

In the studies where Kelly et al. were searching for the availability of usage of venous PH and PCO_2 values instead of arterial PH and PCO_2 values in acute respiratory failure cases, they found out that venous PH could be used for that purpose safely, calculated that venous PCO_2 value is 5.8 mmHg higher than arterial PCO_2 and concluded that venous PCO_2 value is not sufficient to be used in place of arterial PCO_2. They stated that venous PCO_2 could only be used to monitor hypercarbia (11).

In another study conducted in 2004, Kelly et al. examined the compatibility of arterial and venous HCO_3^- values in patients who require blood gas analysis for metabolic or respiratory reasons and stated that venous HCO_3^- value could be calculated in place of arterial HCO_3^- (12). In a similar study, usability of venous blood samples in place of arterial blood samples in terms of PH, PCO2, HCO3- in cases of acute respiratory failure followed by mechanical ventilation in intensive care unit was examined and they found out that even in acute respiratory failure cases, venous blood samples can be used instead of arterial PH, PCO2 and HCO3- values (13).

In another study conducted in Turkey, correlation between PH, PO2, PCO2 and HCO3- values in arterial, vein and capillary blood samples in patients undergoing pediatric intensive care was examined and as a result, it was suggested that in the cases where follow up of regular blood pressure measurement and PO2 wasn't needed, capillary and venous blood gas samples could be alternatives to arterial samples (14).

In our study, when the correlation values of arterial and venous blood gases were examined, it was found that there is a very strong positive correlation between PH, HCO_3^-values. Venous HCO_3^- value was found to be on average 2.8 mmol/L (22.7-19.9 = 2.8) higher than arterial HCO_3^-. These values we have found are consistent with similar studies in the literature (15,16). Therefore, in accordance with the literature, we reached the conclusion that venous PH can be used in place of arterial PH and venous HCO_3^- values can be used instead of arterial HCO_3^-values.

Likewise, we have found that there was a very strong positive correlation between lactate and BE_{ecf} values. It shows that in emergency patients, venous blood lactate measurements could be used instead of arterial lactate measurements and venous blood BE_{ecf} measurements could be used instead of BE_{ecf} measurements. Venous blood samples can be used in substitution for arterial blood specimens to guess the arterial hyperlactacidemia and in situations where we need to assess base excess and deficit in patients, attended to emergency, in whom metabolic disorder is suspected.

In our study, a strong positive correlation between the PCO_2 values was detected. With these results we obtained, although we do not statistically support the use of venous PCO_2 value instead of arterial PCO_2 value, we think that venous PCO_2 value could give an idea about the assessment of respiratory functions.

Mild positive correlation was detected between the arterial-venous PO_2 and SaO_2 values. There aren't any reported findings in previous similar studies about the PO_2 and SaO_2. Reason

of the mild correlation between arterial and venous PO_2 and SaO_2 we have determined may be the effects of increased tissue oxygen uptake, decreased cardiac output, right-left shunts, low hemoglobin level etc. on venous oxygen pressure (17). In addition, rapid changes in concentrations during the time taken to acquire arterial and venous blood gas samples may also be the reason for the moderate correlation we have detected.

In the study we have conducted, in the cases where venous PO_2 value is higher than 40 mmHg, we have found that arterial SaO_2 value is higher than 90%. We have determined that arterial blood gas values are closer to normal limits in cases where venous PCO_2 values are lower than 40 mmHg. Therefore, we think that in cases where venous PO_2 values are higher than 40 mmHg and venous PCO_2 value is lower than 40 mmHg, arterial blood gas values can be considered to be within normal limits.

Limitations of the Study

The research didn't specifically include a patient spectrum with a certain disease. However, we consider it a limitation that we did not record the statistics of the clinical diagnosis of intubated patients in detail. Further, although the blood samples were collected just before the initiation of the oxygen therapy in the emergency room, most of the patients probably received nasal oxygen during transportation as they were brought by 112 ambulances. That could have affected the blood gas parameters of the patients.

CONCLUSION

Venous blood gas can be used in substitution for arterial blood gas in patients with suspected metabolic disorders. In assessment and close follow-up of respiratory functions, arterial blood gas is preferred. However, venous blood gas values may reduce the need for arterial blood gas when the information VBG gives about the respiratory functions and patient's clinic were evaluated.

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Conflict of Interest

The authors declare that they have no conflict of interests regarding content of this article.

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Ethical Declaration

Ethical approval was obtained from the Hatay Mustafa Kemal University, Medical Faculty Clinical Research Ethics Committee for this study with date 6.5.2015 and number 03, and Helsinki Declaration rules were followed to conduct this study.

Authorship Contributions

Concept: YKE, AK, Design: YKE, AK, Supervising: AK, Financing and equipment: YKE, AK, Data collection and entry: YKE, Analysis and interpretation YKE, AK, Literature search: YKE, AK, Writing: YKE, AK, Critical review: AK.

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