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RESEARCH ARTICLE / ÖZGÜN ARAŞTIRMA

The Feasibility of Venous Blood Gas Instead of Arterial Blood Gas in Patients Hospitalized for Chronic Obstructive Pulmonary Diseases Acute Exacerbation

Kronik Obstrüktif Akciğer Hastalığı Nedeniyle Hastaneye Yatan Hastalarda Arteriyel Kan Gazının Yerine Venöz Kan Gazının Değeri

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ABSTRACT

Objective: Guidelines recommend using arterial blood gas analysis in chronic obstructive pulmonary disease exacerbations (COPDE), but arterial blood sampling is more difficult than venous blood sampling and has higher risk of complications. The objective of the study is to investigate whether venous blood gasses correlate with arterial blood gasses in COPDE.

Material and Methods: It was a one-center cross-sectional study. We compared arterial and venous blood gas measurements of patients with COPDE. We used Bland Altman analysis for correlation and agreement between arterial and venous parameters.

Results: Among 100 patients studied, venous and arterial differences of blood gas parameters pH, HCO_3, and PCO_2 were around the 0 line and were randomly distributed within 95% of the calculated compliance limits. Arterial and venous HCO_3 ($p=0.050$) and PCO_2 ($p=0.011$) showed significant agreement.

Conclusion: Venous HCO_3 and PCO_2 values correlate with arterial values and we concluded that venous blood samples can be used instead of arterial blood gasses in COPDE.

Keywords: Arteries, blood gas analysis, chronic obstructive, pulmonary disease, veins.

ÖZ

Amaç: Kılavuzlar, kronik obstrüktif akciğer hastalığı alevlenmelerinde arteriyel kan gazı analizinin kullanılmasını önermektedir, ancak arteriyel kan örneklemesi venöz kan örneklemesine göre daha zordur ve komplikasyon riski daha yüksektir. Bu çalışmanın amacı, kronik obstrüktif akciğer hastalığında venöz kan gazlarının arteriyel kan gazlarıyla korele olup olmadığını araştırmaktır.

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Gereç ve Yöntemler: Tek merkezli kesitsel olan çalışmada, kronik obstrüktif akciğer hastalığı bulunan hastaların arteriyel ve venöz kan gazı ölçümleri karşılaştırıldı. Arteriyel ve venöz parametreler arasındaki uyumun incelenmesi için Bland Altman analizi kullanıldı.

Bulgular: Yüz hastada yapılan çalışmada kan gazı parametreleri pH, HCO_3 ve PaCO2'nin venöz ve arteriyel farklılıkları 0 çizgisi civarındaydı ve hesaplanan uyum sınırlarının %95'i içinde rastgele dağılım gösteriyordu. Arteriyel ve venöz HCO_3 (p=0,050) ve PaCO2 (p=0,011) belirgin uyum gösterdi.

Sonuç: Venöz HCO_3 ve PaCO2 değerleri arteriyel değerlerle uyumludur ve kronik obstrüktif akciğer hastalığında arteriyel kan gazları yerine venöz kan örneklerinin kullanılabileceği sonucuna varıldı.

Anahtar kelimeler: Arterler, kan gazı analizi, kronik obstrüktif akciğer hastalığı, solunum yolu hastalığı, venler.

INTRODUCTION

Chronic obstructive pulmonary disease exacerbations (COPDE) may result in hypercapnia and respiratory acidosis. It is important to measure pH, PCO_2, and HCO_3 as well as PO_2. Guidelines recommend analyzing arterial blood gas for this purpose.[1–4] It is the gold standard method. However, arterial puncture is difficult, complicated, and painful when compared with vein blood sampling. In addition, venous blood samples are taken for several other purposes and in daily practice. Difficulties of obtaining an arterial blood sample and the risks of its complications have led clinicians to seek an alternative method.[5–8] There is a high correlation between the pH and HCO_3 values of arterial and venous blood and vein blood gas is used in the follow-up of diabetic ketoacidosis. However, there are conflicting results on the correlation between venous PCO_2 and arterial blood values. Studies are done to investigate the introduction of vein blood gas to guide the treatment of COPDE.[9,10]

We investigated the relationship between pH, HCO_3, PCO_2, PO_2 and SO_2 levels in arterial and venous blood samples of patients with COPDE. Our aim was to determine the correlation between arterial and venous blood gas parameters.

MATERIAL AND METHODS

Study Population

The study was done in which is a tertiary chest diseases hospital in We conducted our study on 100 consecutive patients who were hospitalized in the ward for COPDE in January-April 2018 period. All our patients had Type 1 or Type 2 respiratory insufficiency. We recorded their demographic data on a standardized database. COPDE was defined according to the criteria of the Global Initiative for Chronic Obstructive Lung Disease 2021.[3]

Arterial and venous blood samples were taken at room air (FiO2: 0.21) at admission. We took arterial blood samples from the radial artery and venous blood samples from the antecubital vein. Samples were analyzed for pH, PCO_2, HCO_3, PO_2, and SO_2 levels using the ABL Radiometer Copenhagen Brand Blood Gas meter in the shortest possible time. Written informed consent was obtained from the patients. The study was approved by local ethics committee of our institute (Approval date and number: 30/01/2017, 1217, 38346378).

Statistical Analysis

It was a cross-sectional study. Data were expressed as mean ± standard deviation, number (n), and percentage (%). X^2 test was used in the comparison of categorical variables and Student's t-test was used in the comparison of continuous variables. p<0.05 was considered statistically significant. Arterial and venous blood gas tests were evaluated by the Bland-Altman method. Differences and arithmetic averages of arterial and venous blood gas parameters for the Bland Altman method, mean ($\bar{d}$), standard deviation (SD), 95% CL and 95% lower and upper compliance limits (del±[1.96×sd]) were calculated. In this method, the statistical significance of the test agreement of the parameters which are compatible with the distribution was shown by linear regression analysis. For statistical analysis, MedCalc Statistical Software Version 18.11.3 was used for the Statistical Package for Social Sciences (SPSS, Inc., Chicago IL), Version 22, and Bland-Altman method were used.

RESULTS

The mean age of 100 patients was 64.8±11 years and 69 were male. Twenty-four patients never smoked, 52 were ex-smoker, and 24 were active smokers. The minimum, maximum and mean values of arterial and venous blood gas parameters were shown in Table 1. Figure 1 shows Bland-Altman method analysis for arterial and venous pH (1a), PCO_2 (1b), HCO_3 (1c), PO_2 (1d). Venous and arterial differences of blood gas parameters pH, HCO_3, and PCO_2 were around the 0 line and were randomly distributed within 95% of the calculated compliance limits.

Arterial and venous blood gas measurements were statistically significant only for the parameters HCO_3 and PCO_2 (p=0.050 and p=0.011, respectively) Table 2 shows the mean of differences of arterial and venous blood parameters for the Bland-Altman method. Table 3 shows the differential of arterial and venous blood gas values for pH, HCO_3, and PCO_2 which shows compatible distribution in the Bland-Altman method with regression analysis for test compatibility.

Table 1: Minimum, maximum, and average values of arterial (A) and venous (V) blood gas parameters

Blood gas parameters	Min	Max	Mean (±SD)
vpH	7.14	7.59	7.3±0.1
apH	7.20	7.67	7.4±0.1
$vHCO_3$ (mmol/L)	13.8	46.2	29.7±6.0
$aHCO_3$ (mmol/L)	13.0	62.0	30.5±7.1
$PvCO_2$ (mmHg)	33.8	137.0	64.4±21.2
$PaCO_2$ (mmHg)	26.4	123.0	57.3±19.4
PvO_2 (mmHg)	22.0	91.0	47.1±13.5
PaO_2 (mmHg)	41.7	118.0	74.9±16.4
SvO_2 (%)	40.0	99.1	73.3±13.7
SaO_2 (%)	77.3	100.0	94.2±4.4

Min: Minimum, Max: Maximum, SD: Standard deviation.

DISCUSSION

We showed the correlation between arterial and venous blood gas values. Venous blood pH, HCO_3, and PCO_2 values had 55%, 57%, and 80% predictive correlation for arterial blood pH, HCO_3, and PCO_2 values. There was a statistically significant but weak correlation for PO_2 and SO_2 parameters. Arterial and venous blood gas measurements were statistically significant only for the parameters HCO_3 and PCO_2

Arterial puncture is technically difficult and painful procedure with some complications such as local hematoma, infection, arterial occlusion/embolization, which can lead to ischemic injury of the fingers. The pain of arterial puncture can be reduced with local anesthetic agent, but questionnaires show that 91% of residents did not use any anesthesia.[11] In our center we do not use a local anesthetic.

It has been reported that venous blood can be used instead of arterial blood for pH and HCO_3 monitoring in diabetic ketoacidosis follow-up.[9] Gokel studies patients with uremic and diabetic ketoacidosis and reported a weak correlation between arterial vein blood PO_2

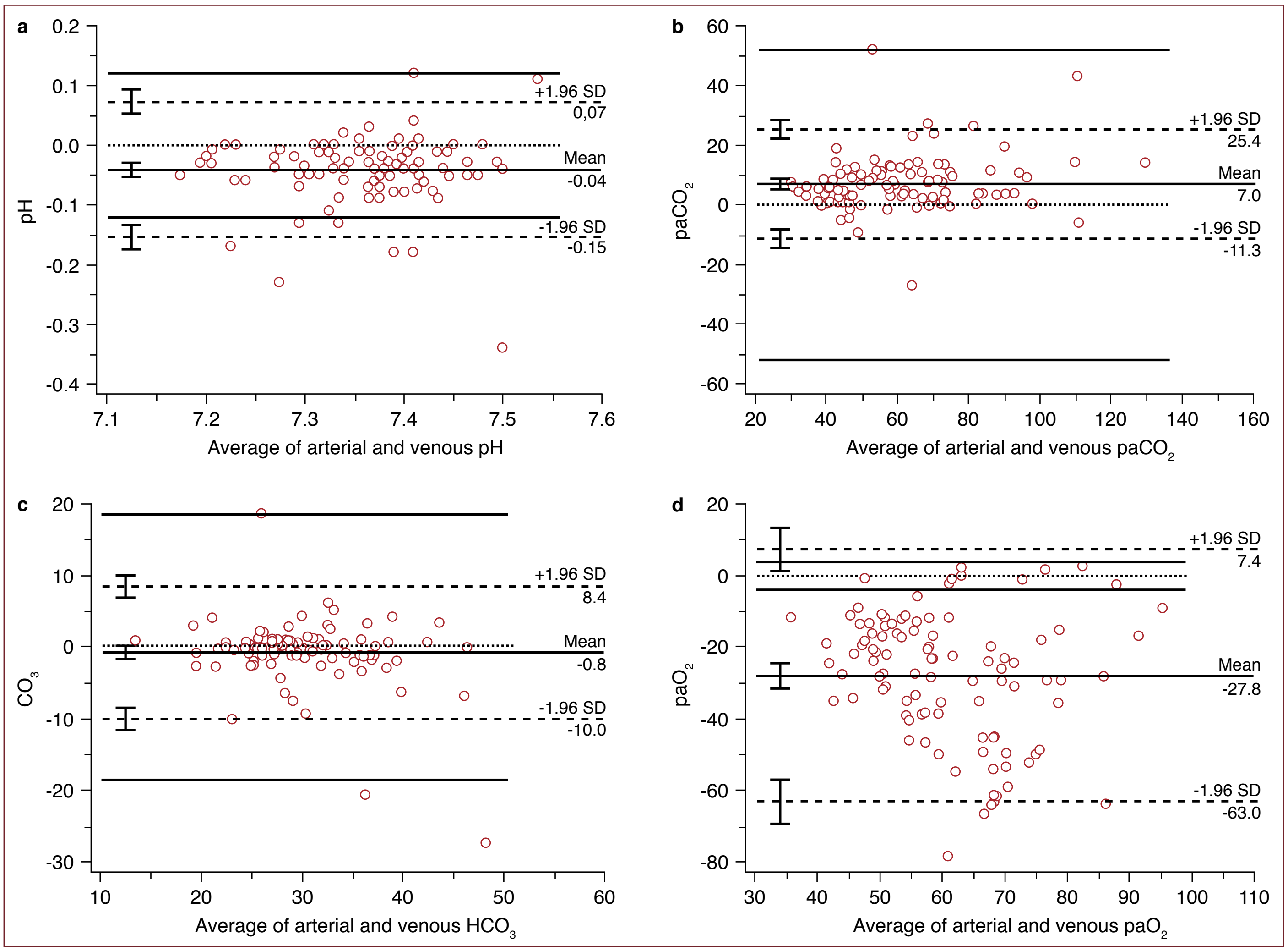

Figure 1: Bland-Altman method analysis for arterial and venous blood gas values, **(a)** Bland-Altman method analysis for arterial and venous pH, **(b)** Bland-Altman method analysis for arterial and venous PCO_2, **(c)** Bland-Altman method analysis for arterial and venous HCO_3, **(d)** Bland-Altman method analysis for arterial and venous PO_2.

Table 2: Mean of differences of arterial and venous blood parameters for Bland-Altman method (D¯), standard deviation (SD), 95% CI, 95% limits of agreement (D For±[1.96×SD])

	D¯	SD	%95 CI	%95 Limits of agreement
pH	–0.04	0.06	–0.05– -0.03	–0.15–0.07
HCO_3	–0.83	4.69	–1.76–0.10	–10.03–8.36
PCO_2	7.03	9.37	5.17–8.89	–11.33–25.40
PO_2	–27.81	17.97	–31.38– -24.25	–63.02–7.40
SO_2	–20.92	12.67	–23.43– -18.40	–45.77–3.93

CI: Confidence interval.

Table 3: Differential of arterial and venous blood gas values for Ph, HCO_3, and PCO_2 which shows compatible distribution in Bland-Altman method with regression analysis for test compatibility

Arterial and venous blood gas parameters	Beta	p
Arterial and venous pH	0.041	0.596
Arterial and venous HCO_3	–0.195	0.011
Arterial and venous PCO_2	0.093	0.050

and SO_2 values, and he reports that venous oxygen pressure may be affected by many factors such as right-to-left shunts, increased oxygen uptake by the tissues, decrease in cardiac output, low hemoglobin level, the time between blood draw and study. However, he emphasizes that the arterial SO_2 value is above 90% in patients with venous PO_2 values higher than 40 mmHg.[12] Our results were consistent with their study and we found a weak correlation between arterial-venous PO_2 and SO_2. However, arterial, and venous PCO_2, HCO_3, and pH values should show agreement in COPD patients to be used in clinical practice.[13]

There are studies on the agreement between arterial and venous blood samples of different study cohorts. Martin performs a study in a general intensive care unit and shows that there was a perfect correlation for pH and PCO_2 in arterial and venous blood[14] for all intensive care unit (ICU) patients. Malatesha[6] studies patients presenting at an emergency department and shows that arterial and venous values of pH, HCO_3, and PCO_2 show acceptably narrow 95% limits of agreement (0.13– -0.1, 4.3– -5.8 and 6.8– -7.6, respectively). He states that agreement in PO_2 measurements is poor (95% limits of agreement 145.3– -32.9).

Lim[10] shows that the weighted average difference for PCO_2 is 5.92 mmHg, whereas those for pH, PO_2, and HCO_3 are 0.028, 18.65 mmHg, and 1.34 mEq/l, respectively. Using Bland-Altman analysis, the 95% limits of agreement are in the range of –0.10–0.08, –17–26 mmHg and, –3.5–3.5 mEq/l for pH, PCO_2, and HCO_3, respectively. Reported cutoff pVBG pCO_2 values for screening of arterial hypercarbia ranged from 30 to 46 mmHg.

In her first study,[7] Kelly shows that the arterial and venous blood pH values of acute respiratory disease patients quite correlate, while the venous PCO_2 levels are 5.8 mmHg higher and the 95% compliance limit is between –8.8 and +20.5. In her second study,[5] she shows that the weighted mean arteriovenous difference in pH is 0.035. The weighted mean arterio–venous difference for pCO_2 is 5.7 mmHg, but with 95% limits of agreement up to the order of ±20 mmHg. For HCO_3, the weighted mean difference between arterial and venous values is –1.41 mmol/L, with 95% limits of agreement of the order of ±5 mmol/L. In another review of the same researcher, she points out that the compliance for PCO_2 was weak but venous PCO_2 ≤45 mm Hg was sufficient to exclude the clinical hypercarbia.[15]

McKeever studies COPDE patients and shows that venous and arterial pH and HCO_3 levels are comparable in COPD patients and that correlation is low for PCO_2.[16] In another study, there is a strong correlation between arterial and venous blood samples for pH, PCO_2, HCO_3 values (r-values 0.778, 0.728, 0.823, p<0.0001, respectively).[17]

The previous literature shows that the correlation of pH and HCO_3 values are high and PCO_2 correlation is variable. In our study, venous PCO_2 levels were 7.03 mmHg higher and the 95% compliance limit for PCO_2 was between –11.33 and +25.40. Venous pH levels were 0.04 lower and the 95% compliance limit for pH was between –0.15 and+0.07. Venous HCO_3 levels were 0.83 mmol/L lower and the 95% compliance limit for HCO_3 was between –10.03 and+8.36. Venous PO_2 was 27.81 mmHg lower and the 95% compliance limit for PO_2 was between –63.02 and +7.4. Venous SO_2 levels were 20.92% lower and the 95% compliance limit for SO_2 was between –45.77 and +3.93. 95% compliance limit of PO_2 and SO_2 are in a wide unacceptable range and venous values cannot be used to estimate arterial gasses. However, PCO_2 levels were similar to Kelly,[9] Malatesha[6] and Martin.[14] We agree with Kelly's statement that venous PCO_2 ≤45 mm Hg was sufficient to exclude the clinical hypercarbia.[15]

95% compliance limit variance may be due to the study population. Some of the previous studies were performed in patients who admitted to the emergency department or ICU. These patients were heterogeneous with various severity and they had metabolic and/or respiratory diseases. Our study group was more homogeneous. Furthermore, it is known that the correlation between arterial and venous pH was weaker in patients with severe hemodynamic impairment.[17,18] Some of our patients had severe COPD exacerbations that might have resulted in hemodynamic impairment.

Weaknesses of the study were; even if the assistants-nurses are experienced, we cannot say that the risk of mixed sampling has been reset. Comorbidities of our patients were not taken into consideration. Cardiac failure or hypotension may result in an increase in arteriovenous oxygenation difference, hemodynamic impairment of our patients was not recorded.

CONCLUSION

Venous blood can be used in COPD exacerbation due to less pain during sampling. There is a correlation and agreement between arterial and venous pH, HCO_3, and PCO_2 values. Because venous PO_2 and SO_2 do not agree with arterial values, oxygen desaturation can be re-evaluated with pulse oximeter.

Disclosures

Ethics Committee Approval: The study was approved by The Health Sciences University Dr. Suat Seren Chest Diseases and Surgery Training and Research Hospital Ethics Committee granted approval for this study (date: 30/01/2017, number: 1217, 38346378).

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