

Comparison of End Tidal Carbon Dioxide and Arterial Blood Bicarbonate Levels in Patients With Exacerbation Chronic Obstructive Pulmonary Disease

Ali Taghizadieh¹; Farzad Rahmani^{2,*}; Hassan Soleimanpour³; Hadi Aminifazl⁴

¹Tuberculosis and Lung Disease Research Center, Tabriz University of Medical Sciences, Tabriz, IR Iran

²Road Traffic Injury Research Center, Tabriz University of Medical Sciences, Tabriz, IR Iran

³Cardiovascular Research Center, Tabriz University of Medical Sciences, Tabriz, IR Iran

⁴Student's Research Committee, Tabriz University of Medical Sciences, Tabriz, IR Iran

*Corresponding author: Farzad Rahmani, Road Traffic Injury Research Center, Tabriz University of Medical Sciences, Tabriz, IR Iran. Tel: +98-4135498144, Fax: +98-4135412151, E-mail: Rahmani@tbzmed.ac.ir

Received: December 17, 2014; **Revised:** February 13, 2015; **Accepted:** February 20, 2015

Background: Arterial Blood Gases (ABG) is performed as the gold standard for monitoring oxygenation and assessing the amount of arterial CO₂ retention in patients with acute exacerbation of Chronic Obstructive Pulmonary Disease (COPD), which is an invasive procedure and can just do discontinuous monitoring of oxygenation and retention of CO₂. Capnography as a noninvasive tool, can show the amount of end tidal CO₂ (ETCO₂).

Objectives: The aim of this study was to compare the values of ETCO₂ with arterial bicarbonate levels in patients with exacerbation of COPD.

Patients and Methods: This was an analytical cross-sectional study performed in the Department of Emergency Medicine of Tabriz University of Medical Sciences on patients with COPD admitted to the emergency ward of Imam Reza hospital. Levels of ETCO₂ with arterial bicarbonate were compared in patients with COPD.

Results: Fifty-seven patients were enrolled; 35 patients (62.5 %) were male. The mean of ETCO₂ and PaCO₂ of patients were 41.49 ± 9.80 and 64.74 ± 9.76, respectively. The mean of PaCO₂ was significantly more than the means of ETCO₂ in patients with COPD. The association between arterial bicarbonate and ETCO₂ was weak and not significant (P = 0.136 and r = 0.04).

Conclusions: Capnography can be used to assess the status of patients with respiratory acidosis in a noninvasive way.

Keywords: Pulmonary Disease, Chronic Obstructive; Blood Gas Analysis; Acidosis, Respiratory

1. Background

COPD (Chronic Obstructive Pulmonary Disease) is the fourth leading cause of death worldwide. Acute exacerbation of COPD like asthma attacks is associated with viral infections (1). Patients with COPD have a very low quality of life; the disease affects daily and social activities of these patients (2).

Wave capnography is indicator of continuous and quantitative measurement of expiratory CO₂ (3). In patients with normal pulmonary function (apart from the age), the difference between ETCO₂ and arterial carbon dioxide partial pressure (PaCO₂) is constant (2 - 5 mmHg). This difference arises from the normal pulmonary alveolar dead space that does not affect ventilation (4). Changes in the shape of capnogram is diagnostics for disease conditions. Changes in ETCO₂ can be used to assess disease severity and response to treatment (5).

In COPD condition or any cause of COPD or bronchospasm, the slope of ascending part of the capnogram curve, decreases as a shark fin called the shark sign. This

pattern is more common in patients with asthma and COPD. The curve's shape helps physicians to differentiate COPD from other causes of acute dyspnea, such as congestive heart failure (4). A defect of capnography in COPD, is that in these patients, ETCO₂ measured by this method is not completely consistent with arterial CO₂. However, capnography is a useful tool in treatment follow-up. There is a poor correlation between ETCO₂ and PCO₂ in respiration rate over than 30 per minute (5). At the study of Abdurrahman and his colleagues, 150 patients were evaluated in a six-month period; they observed a strong linear correlation between ETCO₂ and PCO₂ (6). Researchers found a strong correlation between ETCO₂ and PaCO₂ (7).

2. Objectives

The aim of this study was to compare the values of ETCO₂ with arterial bicarbonate in patients with COPD exacerbation.

3. Patients and Methods

This study was a cross-sectional analysis study performed at Emergency Medicine Department of Tabriz University of Medical Sciences, on patients with COPD referred to Imam Reza hospital. ETCO₂ levels were compared with blood bicarbonate in patients with COPD. To determine the sample size, the results of Mutlu Kartal and his colleagues study were used. In this study, in 25 mmHg ETCO₂, 43% sensitivity and 83% specificity and in 35 mmHg ETCO₂, 43% sensitivity and 83% specificity were determined. Finally, 50 samples were considered. To increase the accuracy of study, 57 patients entered the study (3). The current study was verified by the ethics committee of Tabriz University of Medical Sciences. Informed consent was obtained from each patient included in the study.

Inclusion criterion was all nonintubated patients with COPD admitted to the emergency department. Exclusion criteria were all patients with suspected sepsis, acute gastroenteritis, acute renal failure, diabetic ketoacidosis and any cause of acidosis other than COPD, patients who could not tolerate capnography, patients with impaired consciousness and lack of consent to participate in the study.

For all patients, after obtaining an ethical informed consent, capnography with Side Stream method using RESPIRONICS device (model number: 7100, RESPIRONICS, California Inc. California, USA) was performed with a nasal cannula. In these patients, initially, capnometry was performed and ETCO₂ was recorded. Simultaneously pH, PaCO₂ and bicarbonate were measured and recorded based on ABG results using AVL 995 analyzer of arterial blood gases. To avoid human errors, ABG sampling and recording of ETCO₂ values were performed by a single person. PaCO₂ levels above 45 mm Hg considered as respiratory acidosis. Then, capnography results were compared with the results of ABG.

SPSS 15.0 statistical software was used for data analysis. To determine normal distribution of data, Kolmogorov-Smirnov test was used. Descriptive statistical methods (Mean ± SD), frequency and percentage were used to describe data. Chi-square or Fisher's exact test was used to compare qualitative data. Spearman test was used to evaluate the association between ETCO₂ and PaCO₂. In all cases, P value < 0.05 was considered significant.

4. Results

In this study, 57 patients with COPD referred to the emergency department of Imam Reza medical research and training hospital were selected. Thirty-five (62.5%) patients were male. The mean age of patients was 68.40 ± 11.30 years. Results of vital signs and laboratory findings in patients are presented in Table 1.

The mean of PaCO₂ and ETCO₂ were 64.74 ± 9.75 and 41.49 ± 9.80, respectively. The mean of PaCO₂ in patients was significantly more than the mean of ETCO₂ (P <

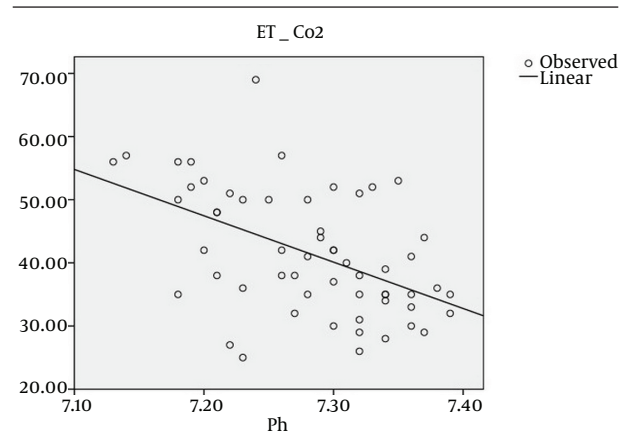
0.001). There was a significant reverse linear association between ETCO₂ and pH of arterial blood in studied patients (P < 0.001 and r = -0.249, Figure 1). There was a significant linear association between levels of ETCO₂ with PaCO₂ in the studied patients (P < 0.001 and r = 0.611, Figure 2). There was no significant association between ETCO₂ and arterial blood bicarbonate in studied patients (P = 0.136 and r = 0.04, Figure 3).

Table 1. Results of Laboratory Finding and Vital Signs of Our Study Patients^a

Variables	Values
Vital Signs	
Systolic Blood Pressure, mmHg	121.05 ± 17.08
Systolic Blood Pressure, mmHg	73.77 ± 10.18
Heart Rate, bpm	93.96 ± 13.26
Respiratory Rate, Per/min	22.70 ± 5.64
Body Temperature, °C	36.87 ± 1.33
O ₂ sat	81.85 ± 8.61
Lab Finding	
White Blood Cells, ×10 ⁹ /L	9635 ± 3208
Hemoglobin, g/L	14.48 ± 2.33
Urea, mmol/L	51.00 ± 14.30
Creatinine, mg/dL	1.25 ± 0.38
Blood Sugar, mmol/L	132.35 ± 44.90
ABG Results	
pH	7.28 ± 0.07
PaCO ₂ , mmHg	64.74 ± 9.76
HCO ₃ , mmol/L	29.81 ± 4.94
End Tidal CO ₂ , mmHg	41.49 ± 9.80

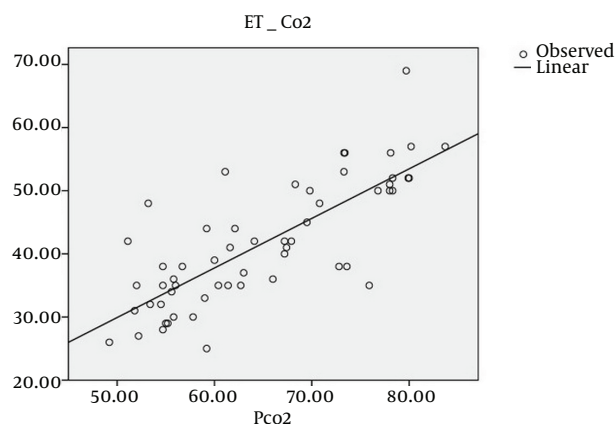
^a Data are presented as No. (%).

Figure 1. The Correlation Between pH and ETCO₂ in Patients With COPD



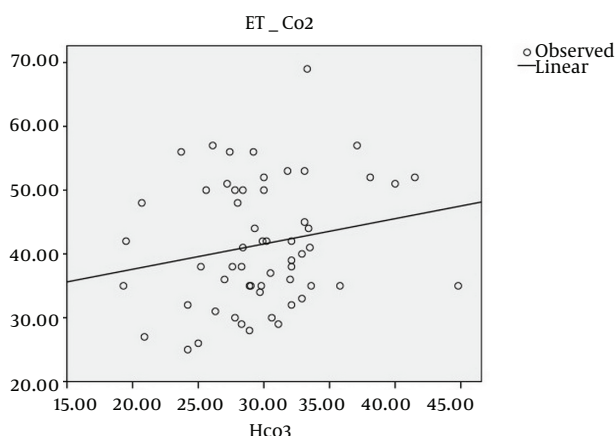
(r = -0.249).

Figure 2. The Correlation Between PaCO₂ and ETCo2 in Patients With COPD



(r = 0.611).

Figure 3. The Correlation Between HCO₃ and ETCo2 in Patients With COPD



(r = 0.04).

5. Discussion

In our study, we compared ABG findings of patients with COPD and ETCo2. Our study found no significant association between ETCo2 and arterial blood bicarbonate ($P = 0.136$ and $r = 0.04$), but there was a significant association between ETCo2 with pH and PaCO₂ ($P < 0.001$ and $r = -0.249$, $P < 0.001$ and $r = 0.611$, respectively).

Measurement of ABG is the gold standard for monitoring oxygenation and assessing the PaCO₂ retention in patients with acute exacerbation of COPD. This procedure is invasive and costly and can just do intermittent monitoring of oxygenation and PaCO₂. However, capnography is a method measuring the amount of carbon dioxide in exhaled breath air and used for monitoring CO₂ levels. PaCO₂ is one of the factors determining blood PH, thus, its changes may produce problems for patient. Capnog-

raphy in the recent years has become more spread and changed to a common method (8). Mechanism of capnography is to determine end-tidal partial pressure of carbon dioxide (ETCo2). It is closely related to PaCO₂ (9). Capnography is a simple, inexpensive and noninvasive method and used at patients' bedside (10).

Continuous measurement of ETCo2 with capnography is one of the ways to evaluate general anesthesia in operating room and used for intubated patients, but this method can even be a noninvasive, rapid and reliable method for predicting PaCO₂ in non-intubated patients. This measurement allows estimation of arterial carbon dioxide pressure without arterial blood sampling. If there is a constant association between end-tidal and arterial carbon dioxide pressure, this method is reliable and no need to frequent blood sampling. Using this method can quantitatively and reliably provide necessary information about patient's respiratory status (4, 10). In a study conducted by Magi and his colleagues (11) it was identified that in normal conditions, ETCo2 is a useful tool for monitoring PaCO₂. But its accuracy relationship with PaCO₂ may be reduced when using standard surgical techniques and different positions. However, predicted results of PaCO₂, according to capnography are questionable and in different clinical conditions, previous studies reported conflicting results (12, 13). Some researchers attempted to measure ETCo2 by capnography to substitute ABG in clinical situations, but the results were not consistent. In a healthy adult, under natural conditions, ETCo2 levels is approximately 2 to 5 mm Hg less than PaCO₂ (4). In a study conducted by Yosefy and colleagues (12) ETCo2 was successful to predict PaCO₂ levels in patients of emergency department with respiratory distress. However, in another study by Warner on patients with trauma who underwent intubation, a poor correlation was reported between the results of PaCO₂ and ETCo2 (13). Delerme and colleagues, evaluated ETCo2 and PaCO₂ in COPD patients and found a significant association between the level of ETCo2 and PaCO₂ (13). A study conducted by Yazigi (14) demonstrated that ETCo2 can be used for monitoring retained CO₂ in obese patients in the recovery room following bariatric surgery.

In patients with pulmonary diseases along with shunt or mismatch of ventilation perfusion, studies indicated that the gradient of PaCO₂-ETCo2 increases due to an increase in dead space ventilation. Aging likely with an increase in dead space can increase PaCO₂-ETCo2 gradient (4, 15). The results of our study indicated a weak direct correlation between blood bicarbonate levels in patients with ETCo2. A strong and significant association was found between ETCo2 and PaCO₂. Therefore, if our results be confirmed in future studies with larger sample size, it is recommended to use capnography instead of ABG in COPD patients admitted to emergency department.

One of the limitations of our study, given the descriptive nature of the study, was lack of a control group. During the study period, we were not able to do capnography

for all patients with COPD admitted to our emergency. Moreover, some patients were excluded due to severe respiratory distress or impairment of consciousness.

Based on the results of our study, the association between arterial bicarbonate and ETCO₂ was weak and not significant. Considering CO₂ retention in patients with COPD, there was not a good association between PaCO₂ and ETCO₂.

Acknowledgements

The authors are grateful to all health personnel and patients participated in the study, in addition to data collectors, supervisors and administrative staff of the Emergency Department of Imam Reza Hospital. This manuscript was written based on a dataset of MD thesis, registered in Tabriz University of Medical Sciences.

Authors' Contributions

All authors read and approved the manuscript. Ali Taghizadieh, Farzad Rahmani and Hadi Aminifazl performed data collection, literature review and drafting of the manuscript. Hassan Soleimanpour undertook major parts of the study design and performed the statistical analysis.

References

1. Strayer RJ. Acid- Base Disorders. In: Marx J editor. *Rosen's Emergency Medicine*. Philadelphia: Mosby; 2014. pp. 1604-14.
2. Attaran D, Khajedaloui M, Jafarzadeh R, Mazloomi M. Health-related quality of life in patients with chemical warfare-induced chronic obstructive pulmonary disease. *Arch Iran Med*. 2006;**9**(4):359-63.
3. Kartal M, Eray O, Rinnert S, Goksu E, Bektas F, Eken C. ETCO₂: a predictive tool for excluding metabolic disturbances in nonintubated patients. *Am J Emerg Med*. 2011;**29**(1):65-9.
4. Soleimanpour H, Gholipouri C, Golzari SEJ, Rahmani F, Sabahi M, Mottram AR. Capnography in the emergency department. *Emergency Med*. 2012;**2**:e123.
5. Kim HT. Arterial Puncture and Cannulation. In: Roberts J editor. *Clinical Procedures in Emergency Medicine*. United States of America: Saunders; 2014. pp. 368-84.
6. Fearon DM, Steele DW. End-tidal carbon dioxide predicts the presence and severity of acidosis in children with diabetes. *Acad Emerg Med*. 2002;**9**(12):1373-8.
7. Naglar J, Krauss B. Devices for Assessing oxygenation and ventilation. In: Roberts J editor. *Clinical Procedures in Emergency Medicine*. United States of America: Saunders; 2014. pp. 23-38.
8. Takano Y, Sakamoto O, Kiyofuji C, Ito K. A comparison of the end-tidal CO₂ measured by portable capnometer and the arterial PCO₂ in spontaneously breathing patients. *Respir Med*. 2003;**97**(5):476-81.
9. Rahmani F, Soleimanpour H, Ebrahimi-Bakhtavar H. Effect of Neck Collar on Pulmonary Function in Multiple Trauma Patients. *Emergency Medicine: Open Access*. 2014;**4**:e138.
10. Soleimanpour H, Taghizadieh A, Niafar M, Rahmani F, Golzari SE, Esfanjani RM. Predictive value of capnography for suspected diabetic ketoacidosis in the emergency department. *West J Emerg Med*. 2013;**14**(6):590-4.
11. Magi E, Multari G, Recine C, Barberio O, Becattini G, Tellini A. [Difference between arterial and end-tidal carbon dioxide tension during surgery of lumbar herniated disk in general anesthesia]. *Minerva Anesthesiol*. 1994;**60**(7-8):381-6.
12. Yosefy C, Hay E, Nasri Y, Magen E, Reisin L. End tidal carbon dioxide as a predictor of the arterial PCO₂ in the emergency department setting. *Emerg Med J*. 2004;**21**(5):557-9.
13. Warner KJ, Cuschieri J, Garland B, Carlbom D, Baker D, Copass MK, et al. The utility of early end-tidal capnography in monitoring ventilation status after severe injury. *J Trauma*. 2009;**66**(1):26-31.
14. Yazigi A, Zeeni C, Richa F, Chalhoub V, Sleilaty G, Noun R. The accuracy of non-invasive nasal capnography in morbidly obese patients after bariatric surgery. *Middle East J Anaesthesiol*. 2007;**19**(3):483-94.
15. Nagler J, Krauss B. Capnographic Monitoring in Respiratory Emergencies. *Clinical Pediatric Emergency Medicine*. 2009;**10**(2):82-9.