Research Paper

Investigating the Relationship Between End Tidal Carbon Dioxide and Arterial Carbon Dioxide Pressure in Patients With Respiratory Distress Referred to the Emergency Room of Hazrat Rasool Akram Hospital

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ABSTRACT

Background: Measuring end-tidal carbon dioxide ($ETCO_2$) can be a non-invasive, fast, and reliable method to predict partial pressure of carbon dioxide ($PaCO_2$) in patients with respiratory distress. This method, which can be a suitable substitute to measure $PaCO_2$, is being used in many emergency rooms and operating rooms in developed countries, but its exact relationship with $PaCO_2$ has not been confirmed yet. This study aims to investigate the relationship between $PaCO_2$ and $ETCO_2$ in patients with respiratory distress referred to the emergency.

Materials and Methods: Arterial blood gases were measured in patients referred to the emergency room of Hazrat Rasool Akram (PBUH) Hospital with the main complaint of respiratory distress, and the $ETCO_2$ of the patient was measured simultaneously with a capnograph. At the same time, the blood pressure and body temperature of the patients were also measured. The obtained information was collected in a sheet and statistically analyzed using SPSS software, version 15.

Results: A total of 120 patients were included in the study whose mean age was 48.3. The Mean $PaCO_2$ and $ETCO_2$ were 47.45 and 26.9, respectively. The mean respiratory rate was 37.4 and diastolic (89.9) and systolic (124.9) blood pressure. A total of 48.33% of patients were women. Statistical analysis showed a significant relationship between $PaCO_2$ and $ETCO_2$ (P=0.0001; CC=0.436). Linear regression analysis showed that $ETCO_2$ predicts $PaCO_2$ with R=0.424.

Conclusion: A good correlation was found between $PaCO_2$ and $ETCO_2$ and this correlation was higher in diseases such as sepsis and COPD. Variables such as age, sex, and blood pressure did not affect this correlation. Of course, more studies on healthy people are necessary to confirm these findings.

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1. Introduction

Patients referred to the emergency room with the main complaint of respiratory distress need a careful examination of the status of oxygenation, ventilation, and acid-base balance. In this regard, taking Arterial Blood Gases (ABG) from the patient can provide accurate information to the doctor, since ABG devices may not be available in all emergency rooms. Taking arterial blood from the patient is time-consuming and prone to errors, it is very painful for the patient; in addition, in some cases, it needs to be repeated several times. Therefore, the need to find non-invasive methods such as pulse oximetry and capnograph is felt. Also, instead of continuous information, ABG provides intermittent findings about the patient's oxygenation; therefore, it is not ideal for careful monitoring of ill patients [1].

Using capnography, the amount of end-tidal carbon dioxide ($ETCO_2$) can be measured. Capnometry is a non-invasive method to assess the adequacy of ventilation by measuring the concentration of carbon dioxide in exhaled air [2]. Capnometry shows the amount of carbon dioxide per unit of time in the form of a graph in each respiratory cycle.

Capnography can help guide the quality of cardiopulmonary resuscitation. In addition, capnography is useful in determining the adequacy of pulmonary ventilation and evaluating changes in pulmonary blood flow and physiologic dead space [3].

Also, capnography is used in patients who undergo elective surgery under general anesthesia, patients who undergo hyperventilation to reduce cerebral edema, and those who need monitoring for the occurrence of respiratory apnea [4].

Capnography shows alveolar ventilation ($PaCO_2$). If the patient is hemodynamically stable, the ambient temperature is stable and no severe lung disease exists. However, end-tidal carbon dioxide ($PETCO_2$) is significantly affected by changes in physiological dead space, which in turn is affected by pulmonary blood flow and cardiac output. A sudden drop in cardiac output and a decrease in pulmonary blood flow lead to an increase in the physiological dead space and a drop in the amount of $PETCO_2$ and, naturally, an increase in the gradient between arterial and alveolar carbon dioxide pressure. However, the interpretation of capnography numbers in critically-ill patients and patients with acute respiratory failure should be done with caution [5, 6].

2. Materials and Methods

In this analytical cross-sectional study, all patients who were referred to the emergency room of Hazrat Rasool Akram (PBUH) Hospital with respiratory distress during the study period were examined, and $ETCO_2$ and ABG were measured simultaneously by capnograph.

The obtained information was collected in a sheet and statistically analyzed using SPSS software version 15.

$ETCO_2$ measurement has no harm to the patients and ABG was performed as part of the diagnostic process in case of indication (respiratory distress) after obtaining written consent from the patient or companions.

3. Results

A total of 120 patients were included in the study, whose mean age was 48.3. The mean PaCO2 and $ETCO_2$ were 47.45 and 26.9, respectively. The mean respiratory rate was 37.4, diastolic blood pressure was 89.9 and systolic blood pressure was 124.9. A total of 48.33% of the patients were women. A significant statistical relationship was observed between $PaCO_2$ and $ETCO_2$ (Spearman's Correlation; P=0.001 CC=0.436).

A significant statistical relationship was observed between $ETCO_2$ and $PaCO_2$ in Chronic Obstructive Pulmonary (COPD) and sepsis (Table 1). No significant statistical relationship was found between age, breathing rate, and blood pressure with $ETCO_2$ and PaCO2 (Table 2). In linear regression analysis, $ETCO_2$ predicts $PaCO_2$ with R=0.424, P=0.001.

4. Discussion

In our study, a linear correlation between $ETCO_2$ and PaCO2 was shown, which had a correlation coefficient of 0.436. The disproportion between $ETCO_2$ and PaCO2 indicates the difference between ventilated and perfused alveoli. An increase in anatomical and physiological dead space and disturbance in pulmonary blood circulation leads to a decrease in $ETCO_2$ and an increase in the gradient of $ETCO_2$/$PaCO_2$ [7, 8]. In hemodynamically stable patients, a gradient of 5-6 is normal [7, 9, 10]. Pulmonary embolism and shock decrease $ETCO_2$ and increase $PaCO_2$/$ETCO_2$ gradient [11, 12].

A study conducted by Yusefi [13] and Barton [14] showed a linear correlation between $ETCO_2$ and $PaCO_2$, and the correlation coefficient was reported as 0.736 and 0.7720, respectively, which confirms our findings. Also, Yusefi's study showed that increasing age increases the $PaCO_2$/$ETCO_2$ gradient by increasing the dead space in the lung [15].

Table 1. Correlation of log Partial Pressure Of Carbon Dioxide ($PaCO_2$) and End-Tidal Carbon Dioxide ($ETCO_2$) according to diseases

Disease				Log $PaCO_2$
Asthma	Spearman's rho	$ETCO_2$	Correlation coefficient	-0.228
			Sig. (2-tailed)	0.308
			N	22
COPD	Spearman's rho	$ETCO_2$	Correlation coefficient	0.665**
			Sig. (2-tailed)	0.000
			N	28
Pulmonary edema	Spearman's rho	$ETCO_2$	Correlation coefficient	0.200
			Sig. (2-tailed)	0.533
			N	12
Sepsis	Spearman's rho	$ETCO_2$	Correlation coefficient	0.894**
			Sig. (2-tailed)	0.003
			N	8
PTE	Spearman's rho	$ETCO_2$	Correlation coefficient	0.025
			Sig. (2-tailed)	0.933
			N	14

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** Correlation is significant at the 0.01 level (2-tailed); $ETCO_2$: End tidal carbon dioxide; COPD: Chronic Obstructive Pulmonary Disease; PTE: Pulmonary Thromboendarterectomy.

Table 2. Correlation of Partial Pressure of Carbon Dioxide ($PaCO_2$) and End-Tidal Carbon Dioxide ($ETCO_2$) with blood pressure, respiratory rate, and age based on spearman's rho

Variables		Correlation Coefficient	Sig. (2-tailed)
$ETCO_2$	RR	-0.022	0.809
	Age	-0.015	0.869
	Diastolic BP	-0.034	0.713
	Systolic BP	-0.047	0.609
$PaCO_2$	RR	0.109	0.237
	Age	0.137	0.135
	Diastolic BP	-0.010	0.918
	Systolic BP	-0.059	0.522

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$ETCO_2$: End tidal carbon dioxide; $PaCO_2$: Partial pressure of carbon dioxide; BP: Blood pressure; RR: Risk ratio.

In Barton's study [14] , no statistically significant difference was observed between $ETCO_2$ and $PaCO_2$ in patients with hypocapnia, and the correlation between $ETCO_2$ and $PaCO_2$ was stronger. Milo et al. using the genetic algorithm obtained a formula that non-invasively calculates $PaCO_2$ through $ETCO_2$ with an increase in accuracy of 21% compared to other studies [16]. In our study, the $PaCO_2/ETCO_2$ gradient increased with increasing age, but it was not statistically significant.

According to Scaman et al. [17], the capnometer device cannot accurately predict $ETCO_2$ changes with increasing breathing rate and will lead to a low correlation coefficient; nevertheless, in our study and Yusefi's study, the correlation coefficient decreased in respiration rate above 30, but this decrease was not statistically significant.

In this study, the highest correlation coefficient of $ETCO_2$ and $PaCO_2$ according to pathogenesis is as follows, sepsis and COPD, whose correlation coefficient was 0.894, 0.665, respectively, which has a significant statistical difference with the total correlation coefficient denoting that the probability of predicting $PaCO_2$ from $ETCO_2$ in these two diseases is higher. In Yusefi's study, due to the small sample size, these comparisons were not done.

5. Conclusion

A good correlation was found between $PaCO_2$ and $ETCO_2$ and this correlation was higher in diseases such as sepsis and COPD. Variables, such as age, sex, and blood pressure did not affect this correlation. Of course, more studies on healthy people are necessary to confirm these findings.

Ethical Considerations

Compliance with ethical guidelines

There were no ethical considerations to be considered in this research.

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Authors' contributions

All authors equally contributed to preparing this article.

Conflict of interest

The authors declared no conflict of interest.

References

[1] Marx J, Hockberger R, Walls R. Rosen's Emergency Medicine-Concepts and Clinical Practice E-Book: 2-Volume Set. Amsterdam: Elsevier Health Sciences; 2013. [Link]

[2] Roberts JR, Hedges JR. Roberts and Hedges' clinical procedures in emergency medicine E-book. Amsterdam: Elsevier Health Sciences; 2013. [Link]

[3] Carol Rhoades RN,and Frank Thomas :Capnography beyond the numbers ;Air Medical J.21:2 March 2002.43_48. [DOI:10.1016/S1067-991X(02)70085-0] [PMID]

[4] Soubani AO. Noninvasive monitoring of oxygen and carbon dioxide. The American Journal of Emergency Medicine. 2001; 19(2):141-6. [DOI:10.1053/ajem.2001.21353] [PMID]

[5] Bhavani-Shankar K, Moseley H, Kumar AY, Delph Y. Capnometry and anaesthesia. Canadian Journal of Anaesthesia. 1992; 39:617-32. [DOI:10.1007/BF03008330] [PMID]

[6] Bowe EA, Boysen PG, Broome JA, Klein EF. Accurate determination of end-tidal carbon dioxide during administration of oxygen by nasal cannulae. Journal of Clinical Monitoring. 1989; 5:105-10. [DOI:10.1007/BF01617883] [PMID]

[7] Whitesell R, Asiddao C, Gollman D, Jablonski J. Relationship between arterial and peak expired carbon dioxide pressure during anesthesia and factors influencing the difference. Anesthesia & Analgesia. 1981; 60(7):508-12. [DOI:10.1213/00000539-198107000-00008] [PMID]

[8] Stock MC. Capnography for adults. Critical Care Clinics. 1995; 11:219-32. [DOI:10.1016/S0749-0704(18)30093-9] [PMID]

[9] Wahba RW, Tessler MJ. Misleading end-tidal CO_2 tensions. Canadian Journal of Anesthesia/Journal Canadien D'anesthésie. 1996; 43:862-6. [DOI:10.1007/BF03013040] [PMID]

[10] Russell GB, Graybeal JM, Strout JC. Stability of arterial to end-tidal carbon dioxide gradients during postoperative cardiorespiratory support. Canadian Journal of Anaesthesia. 1990; 37:560-6. [DOI:10.1007/BF03006326] [PMID]

[11] Gudipati CV, Weil MH, Bisera JO, Deshmukh HG, Rackow EC. Expired carbon dioxide: a noninvasive monitor of cardiopulmonary resuscitation. Circulation. 1988; 77(1):234-9. [DOI:10.1161/01.CIR.77.1.234] [PMID]

[12] Hatle L, Rokseth R. The arterial to end-expiratory carbon dioxide tension gradient in acute pulmonary embolism and other cardiopulmonary diseases. Chest. 1974; 66(4):352-7. [DOI:10.1378/chest.66.4.352] [PMID]

[13] Yosefy C, Hay E, Nasri Y, Magen E, Reisin L. End tidal carbon dioxide as a predictor of the arterial PCO_2 in the emergency department setting. Emergency Medicine Journal. 2004; 21(5):557-9. [DOI:10.1136/emj.2003.005819] [PMID] [PMCID]

[14] Barten CW, Wang ES. Correlation of end-tidal CO2 measurements to arterial PaCO2 in nonintubated patients. Annals of Emergency Medicine. 1994; 23(3):560-3. [DOI:10.1016/S0196-0644(94)70078-8] [PMID]

[15] Wahba WM. Influence of aging on lung function-clinical significance of changes from age twenty. Anesthesia & Analgesia. 1983; 62(8):764-76. [DOI:10.1213/00000539-198308000-00011] [PMID]

[16] Engoren M, Plewa M, O'Hara D, Kline JA. Evaluation of capnography using a genetic algorithm to predict $PaCO_2$. Chest. 2005; 127(2):579-84. [DOI:10.1378/chest.127.2.579] [PMID]

[17] From RP, Scamman FL. Ventilatory frequency influences accuracy of end-tidal CO_2 measurements analysis of seven capnometers. Anesthesia & Analgesia. 1988; 67(9):884-6. [DOI:10.1213/00000539-198809000-00016]

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