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Investigation of the relationship between end-tidal carbon dioxide and partial arterial carbon dioxide pressure in patients with respiratory distress

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Blood gas test is requested when a person shows either signs of imbalance in oxygen/carbon dioxide or pH, such as difficulty in breathing, shortness of breath, vomiting, suffering from respiratory illness, metabolic disorder, kidney disease, and experiencing respiratory failure, or injuries that could affect breathing, including head or neck trauma. Therefore, measuring blood gas is highly important for assessing oxygenation and acid/base situation (1-3). Patients admitted to the emergency wards with respiratory distress as their main complaint need careful examination for oxygenation status, ventilation, and acid/base balance (4, 5).

Taking the arterial blood gas (ABG) test from the patient can provide valuable information for the physician. Unfortunately, ABG apparatus may not be available in all emergency wards (6-8). Arterial blood taking from the patient is time-consuming and very painful, has error probability, and needs to be repeated several times in some cases. Thus, using noninvasive methods such as pulse oximetry and capnography is necessary (9, 10). On the other hand, ABG test provides steady information on the patients' oxygenation instead of providing intermittent findings. In sum, ABG is not ideal to monitor critically-ill patients (11, 12). However, end-tidal carbon dioxide pressure can be measured using capnography (13).

End-tidal CO_2 can be a noninvasive, quick, and reliable technique which predicts $PaCO_2$ in patients with respiratory distress (14). Monitoring end-tidal Co_2 could be a suitable substitute for measuring $PaCO_2$ in many emergency wards and operating rooms in developed countries (15). However, to date, exact correlation with $PaCO_2$ has not been confirmed. This study aimed to evaluate the correlation between $PaCO_2$ and $EtCO_2$ in patients with respiratory distress admitted to the emergency wards.

In this cross sectional study, the ABG test was taken and simultaneously the $EtCO_2$ was measured with capnograph in patients admitted to the emergency ward of Hazrat-e Rasoul hospital with one or more following symptoms: difficulty breathing, grunting, tachypnea, orthopnea, costal retraction, bluish color around mouth, wheezing, and nasal flaring described as respiratory distress symptoms (16). Also, blood pressure and body temperature of the patients were recorded. Then, patients diagnosed as newborn respiratory distress syndrome were excluded. In this study, the sample volume with 30% probability was 120 cases. All patients agreed to provide their information to the researcher.

The collected data were analyzed using SPSS-22. The recorded variables were collected using a predesigned questionnaire and analyzed using regression method.

A total of 120 patients (62 men (51.66%) and 58 women (48.33%), with the age range of 10-90 years (mean: 48.3 years), entered the study. The mean value of their $PaCO_2$ and $EtCO_2$ was 47.45 and 26.9 mmHg, respectively. The mean number of their respiratory rate (RR) was 37.4 bpm, diastolic pressure 89.9 mmHg, and systolic pressure 124.9 mmHg. All demographic data are presented in Table 1.

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Table 1. Demographic data

Variable	Value
Male	62 (51.66%)
Female	58 (48.33%)
Mean age of patients	48.33years (SD=22.53)
Asthma	22 (18.33%)
COPD	28 (23.33%)
Pulmonary Edema	12 (10.0%)
Sepsis	8 (6.67%)
PTE*	14 (11.67%)
Others	36 (30.0%)
Mean Respiratory Rate	37.47bpm (SD=9.4)
Mean Systolic BP**	124.9mmHg (SD=14)
Mean Dystolic BP	89.9mmHg (SD=19)

*PTE: Pulmonary thrombosis emboli, **BP: Blood pressure

Based on the results, there was a significant statistical difference between $PaCO_2$ and $EtCO_2$ (Spearman correlation, p=0.001, CC=0.436).

In this study, no significant difference was found between systolic and diastolic blood pressure with regards to $PaCO_2$ and $EtCO_2$. However, there was a significant difference between $EtCO_2$ and $PaCO_2$ in chronic obstructive pulmonary disease (COPD) and sepsis (Table 2). The statistical difference between $EtCO_2$ and $PaCO_2$ was mentioned separately for each disease.

According to the results, there was no significant statistical difference between $EtCO_2$ and $PaCO_2$ in age (Table 3). Based on the study results, no significant difference was seen between blood pressure as regards to $EtCO_2$ and $PaCO_2$ (Table 4).

In the present study, using Spearman test, no significant difference was found between the respiratory rate as regards to $EtCO_2$ and $PaCO_2$ (Table 5). Also, no significant difference existed between the 2 genders in age, respiratory rate, $EtCO_2$, and $PaCO_2$. In the linear regression analysis, $EtCO_2$, with R=0.424, predicted the level of $PaCO_2$ (p=0.001, Linear Regression).

Blood gas analysis with $EtCO_2$ can be a noninvasive, quick, and reliable method to predict $PaCO_2$ in patients

Table 2. Pearson correlation coeficent of Log PaCO2 and EtCO2 mentioned separately for each disease

	$EtCO_2$	Correlation-coefficient	Log $PaCO_2$
		Correlation-coefficient	-0.228
Asthma	$EtCO_2$	P-Value	0.308
		N	22
		Correlation-coefficient	0.665**
COPD	$EtCO_2$	P-Value	<0.001
		N	28
		Correlation-coefficient	0.200
Pulmonary edema	$EtCO_2$	P-Value	0.533
		N	12
		Correlation-coefficient	0.894**
Sepsis	$EtCO_2$	P-Value	0.003
		N	8
		Correlation-coefficient	0.025
PTE	$EtCO_2$	P-Value	0.933
		N	14

** Correlation is significant at 0.01 level (2-tailed)

Table 3. Spearman correlation coefficent of Log $PaCO_2$ and $ETCO_2$ with age

Correlations			
			Age
		Correlation coefficient	-0.015
	$EtCO_2$	P value	0.869
Spearman rank correlation		n	120
		Correlation coefficient	0.137
	Log $PaCO_2$	P value	0.135
		n	120

Table 4. Spearman correlation coefficent of Log $PaCO_2$ and $EtCO_2$ with blood pressure

Correlations Variable				
			Diastolic BP	Systolic BP
	$EtCO_2$	Correlation coefficient	-0.034	-0.047
		P value	0.713**	0.609
Spearman rank correlation		n	120	120
	Log $PaCO_2$	Correlation coefficient	-0.010	-0.059
		P value	0.918**	0.522
		n	120	120

*BP: Blood Pressure, ** Correlation is significant at 0.01 level (2-tailed)

Table 5. Spearman correlation coefficent of Log PaCO2 and EtCO2 with respiratory rate

Correlations Variable			
			Respiratory Rate
		Correlation coefficient	-0.022
	$EtCO_2$	P value	0.809
Spearman rank correlation		n	120
		Correlation coefficient	0.109
	Log $PaCO_2$	P value	0.237
		n	120

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with respiratory distress. The linear correlation between $EtCO_2$ and $PaCO_2$ was determined and its correlation coefficient was found to be 0.436. The disparity between $EtCO_2$ and $PaCO_2$ was an indicative of the difference between ventilated alveoli and perfuse ones. The increase in anatomical and physiological dead space and disruption in pulmonary blood circulation lead to a reduction in $EtCO_2$ value and an increase in the proportion of $EtCO_2/PaCO_2$. Also, in hemodynamically stable patients, the gradient of 5-6 is normal (17-19). Pulmonary embolism and shock cause $EtCO_2$ reduction and increase in the gradient of $PaCO_2/EtCO_2$ (17, 20).

In the study by Yosefy (19), a linear correlation was found between $EtCO_2$ and $PaCO_2$ and the correlation coefficient was reported as 0.736 and 0.772, respectively. These findings confirmed our results. Also, Yosefy showed that aging leads to an increase in the gradient of $PaCO_2/EtCO_2$ through the increase of dead space in the lungs.

In this study, it was found that as age increased, the $PaCO_2/EtCO_2$ gradient also increased, but the increase was not significant, which was consistent with other studies. According to Scaman et al (20), capnometer is not able to accurately predict the changes in $EtCO_2$ when respiratory rate increases and will lead to low correlation coefficient. Likewise, in the present study and Yosefy study, the correlation coefficient reduced when the respiratory rate was above 30, but this reduction was not statistically significant.

The highest correlation coefficient of $EtCO_2$ and $PaCO_2$, according to the pathogenesis, was seen between sepsis and COPD and their correlation coefficients were 0.894 and 0.665, respectively. This statistically significant difference indicates that in these 2 diseases the probability to predict $PaCO_2$ is more than $EtCO_2$. In the study by Yosefy, these comparisons have not been concluded.

A good correlation was found between $PaCO_2$ and $EtCO_2$; however, this correlation was higher in such diseases as sepsis and COPD. Variables such as age, gender, and blood pressure did not affect this correlation. Nevertheless, further studies are needed to confirm these findings in healthy individuals.

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Conflict of Interests

The authors declare that they have no competing interests.

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