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ORIGINAL ARTICLE

Can end-tidal CO_2 measurement replace arterial partial CO_2 in emergency department respiratory distress management?

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KEYWORDS
End-tidal carbon dioxide;
Respiratory distress;
Arterial carbon dioxide;
Venous carbon dioxide;
Emergency department

Abstract
Objective: To assess the feasibility of using end-tidal carbon dioxide ($EtCO_2$) as a non-invasive substitute for partial pressure of arterial carbon dioxide ($PaCO_2$) in emergency department (ED) triage and follow-up, and to explore the potential of partial pressure of venous carbon dioxide ($PvCO_2$) as an alternative to $PaCO_2$.
Design: Prospective cross-sectional study.
Setting: Tertiary university hospital.
Patients or participants: 97 patients presenting with acute respiratory distress to the ED.
Interventions: $EtCO_2$, arterial blood gases, and venous blood gases measured at admission (0 min), 60 min, and 120 min.
Main variables of interest: CO_2 levels.
Results: Among 97 patients (mean age: 70.93 ± 9.6 years; 60.8% male), $EtCO_2$ > 45 mmHg at admission showed strong positive correlations with $PaCO_2$ and $PvCO_2$ ($r = 0.844$, $r = 0.803$; $p < 0.001$, respectively). Significant positive correlation was observed between 60-min $EtCO_2$ and $PaCO_2$ ($r = 0.729$; $p < 0.001$). Strong correlation between $PaCO_2$ and $PvCO_2$ at 120 min when $EtCO_2$ > 45 mmHg ($r = 0.870$; $p < 0.001$). $EtCO_2$ was higher in hospitalized patients compared to discharged ones.
Conclusions: $EtCO_2$ appears promising as a substitute for $PaCO_2$ in ED patients with acute respiratory distress within the initial two hours of treatment. Venous blood gas sampling offers a less invasive alternative to arterial sampling, facilitating simultaneous blood tests.

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PALABRAS CLAVE
Dióxido de carbono al final de la espiración;
Insuficiencia respiratoria;
Dióxido de carbono arterial;
Dióxido de carbono venoso;
Departamento de emergencias

¿Puede la medición del CO_2 al final de la espiración reemplazar el CO_2 parcial arterial en el tratamiento de la dificultad respiratoria en el departamento de urgencias?

Resumen
Objetivo: Evaluar la viabilidad de utilizar el dióxido de carbono al final de la espiración ($EtCO_2$) como un sustituto no invasivo de la presión parcial de dióxido de carbono arterial ($PaCO_2$) en el triaje y seguimiento en el departamento de emergencias (ED), y explorar el potencial de la presión parcial de dióxido de carbono venoso ($PvCO_2$) como alternativa a $PaCO_2$.
Diseño: Estudio prospectivo transversal.
Ámbito: Hospital universitario terciario.
Pacientes o participantes: 97 pacientes que se presentaron con dificultad respiratoria en el ED.
Intervenciones: Se midieron $EtCO_2$, gases en sangre arterial y gases en sangre venosa al ingreso (0 min), 60 min y 120 min.
Principales variables de interés: Niveles de CO_2.
Resultados: Entre 97 pacientes (edad media: 70,93 ± 9,6 años; 60,8% hombres), $EtCO_2$ > 45 al ingreso mostró correlaciones positivas fuertes con $PaCO_2$ y $PvCO_2$ ($r = 0{,}844$, $r = 0{,}803$; $p < 0{,}001$, respectivamente). Se observó una correlación positiva significativa entre $EtCO_2$ a los 60 min y $PaCO_2$ ($r = 0{,}729$; $p < 0{,}001$). Fuerte correlación entre $PaCO_2$ y $PvCO_2$ a los 120 min cuando $EtCO_2$ > 45 ($r = 0{,}870$; $p < 0{,}001$). $EtCO_2$ fue mayor en los pacientes hospitalizados en comparación con los dados de alta.
Conclusiones: $EtCO_2$ parece prometedor como sustituto de $PaCO_2$ en pacientes del ED con dificultad respiratoria dentro de las dos primeras horas de tratamiento. La toma de muestras de gases en sangre venosa ofrece una alternativa menos invasiva a la toma de muestras arterial, facilitando pruebas de sangre simultáneas.

Introduction

The first point of admission for patients experiencing acute respiratory distress is usually the emergency department (ED). Establishing a safe and protected setting for individuals experiencing respiratory distress is paramount. Furthermore, it is imperative to efficiently detect and diagnose any underlying factors contributing to their shortness of breath. For this reason, measuring devices that evaluate respiratory status with noninvasive, easily applicable, and reliable methods in busy ED environments are of interest. End-tidal carbon dioxide ($EtCO_2$) measurement strengthens its place in clinical practice day by day as a handy and valuable method for evaluating patient ventilation in emergency settings.[1–6]

The use of $EtCO_2$ monitoring is becoming increasingly common in a variety of clinical settings, both prehospital and hospital.[7] In addition to being considered the most reliable confirmation method of the correct placement of the endotracheal tube, it also helps the physician in life support efforts, such as determining the quality of cardiopulmonary resuscitation and detecting the return of spontaneous circulation.[8,9] Capnography is used in various situations, including procedural sedation and analgesia, patient transfer, pulmonary embolism, and acute follow-up of chronic obstructive pulmonary disease (COPD).[10–14]

$EtCO_2$ is the level of carbon dioxide released at the end of expiration. For noninvasive $EtCO_2$ measurement, capnometry, which provides only numerical values, or capnography, which provides both graphical and numerical results, is used. Measurement is made as a mainstream or a sidestream. In sidestream, the CO_2 sensor is located inside the monitor, and a small portion of the exhaled air reaches the breathing circuit through a cable with a delay. In the mainstream type, the CO_2 sensor is directly connected to the breathing circuit and displays the result without delay. While sidestream can be used in intubated and non-intubated patients, mainstream is primarily used in intubated patients.[2,6,12,15] While increased dead space and clogging with secretions are substantial disadvantages in the sidestream type, these are no longer a problem in the mainstream type, and the results are more reliable.[2,6]

Partial pressure of arterial carbon dioxide ($PaCO_2$) is the gold standard for diagnosing and treating patients presenting to the ED with respiratory distress. However, in busy EDs, there is a need for fast, practical, cost-effective, and noninvasive methods that will help us comprehend the severity of patients while they are still in the triage phase. In many of the studies in the literature on non-intubated patients, correlation studies were conducted between $EtCO_2$ measurements obtained through sidestream detectors and $PaCO_2$.[1,16–18]

The main aim of this study is to determine whether the $EtCO_2$ value obtained using the mainstream detector at the first presentation to the ED in non-intubated patients can be safely used instead of the patient's $PaCO_2$ value. The reason for using the mainstream detector, which is used in intubated patients, instead of the sidestream detector in non-intubated patients is that the previously described disadvantages that may alter the measurement results, such as dead space and obstruction by secretions, are less likely to be encountered. The secondary aim of the study was to determine whether partial pressure of venous carbon dioxide ($PvCO_2$) measurement would be an alternative to partial pressure of arterial carbon dioxide ($PaCO_2$) measurement, especially in patients who are not suitable for $EtCO_2$ (confused or intubated). The tertiary aim of the study was to determine whether $EtCO_2$ measurement was associated with hospitalizations.

Methods

Study design and setting

It was planned as a prospective cross-sectional study with patients who presented to the ED with respiratory distress between April and May 2023 (61 days). The study was conducted in the ED of a 317-bed tertiary university hospital with approximately 90,000 patient admissions per year. Local Ethics Committee approval was received for the study (Approval ID: 2023/42, dated March 20, 2023). Patients were included in the study by obtaining informed consent. Patient data were recorded on the study form simultaneously during the patients' application. Descriptive data were obtained from the hospital's electronic database and ED records.

Participants and measurements

Patients with a primary complaint of dyspnea regardless of etiology, older than 18 years of age, able to blow into a capnograph device and followed up in the emergency department for at least 2 h were included in the study. Of the 623 patients admitted to the emergency department with respiratory distress. We excluded 111 patients who refused to participate in the study, 162 patients with confused, uncooperative or ineffective blowing, 87 patients with inconclusive blood gas results due to coagulation, 25 patients undergoing tracheal intubation, 141 patients who have not been in the ED for at least 2 h (Fig. 1). Participation in the study was purely voluntary and not reliant on coercion. Demographic information of the patients, $EtCO_2$ level, $PaCO_2$ and $PvCO_2$ levels, pulse oximetry saturation level (SpO_2), and treatments given were recorded at the moment of first admission (0th minute), 60th minute, and 120th minute. The patients' hospitalization-discharge status, vital signs, and initial blood gas pH values were also noted. Arterial blood gas samples were obtained simultaneously from the radial artery, brachial artery, or femoral artery, and venous blood gas samples were obtained from the brachial vein simultaneously with heparinized syringes and quickly delivered to the laboratory.

Measuring $EtCO_2$

$EtCO_2$ measurements were performed by attaching a 3D-printed disposable apparatus (colorFabb 1.75 mm filament was used with a Creality Ender 3 Pro 3D printer) to the airway adapter of a mainstream EMMA® Capnograph device (PHASEIN AB Svärdvägen, Danderyd, Sweden). It is produced for intubated patients. It was obtained with spontaneous single pulses from patients presenting with respiratory

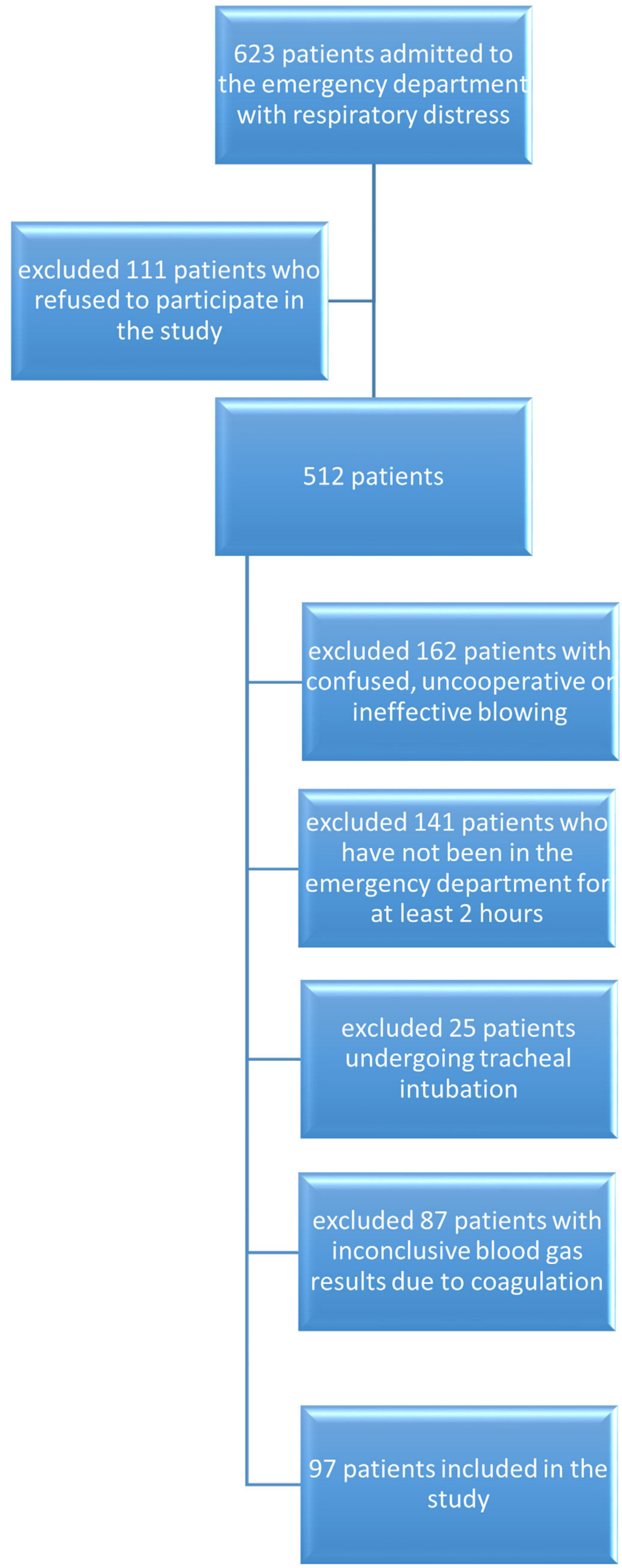

Figure 1 Flowchart of patients excluded from the study.

distress. Carbon dioxide level was classified as follows: <35 mmHg (hypocarbia), 35–45 mmHg (normocarbia), and >45 mmHg (hypercarbia).[19] End tidal carbon dioxide measurement takes 3 s and arterial and venous carbon dioxide measurement takes approximately 10 min.

Statistical analysis

Statistical analyses were performed using SPSS software for Windows, version 23 (IBM, Chicago, IL, United States). Descriptive statistics are presented as numbers and percentages. Demographic data were presented as mean ± standard deviation (SD), or median (interquartile range). Spearman correlation analysis was used for correlation analyses between $EtCO_2$, $PaCO_2$, $PvCO_2$, SpO_2, and cigarette pack/year. If the Spearman correlation coefficient (r) is below 0.20, it is considered an insignificant correlation. A weak correlation is marked between 0.20–0.50, a moderate correlation is observed between 0.50–0.70, and a strong correlation is observed when it is greater than 0.70.[20] Coefficients ¨iẅere given as significance values ¨p.Ċorrelation was considered significant at $p < 0.05$. The Pearson chi-square test and Fisher's exact test (when the expected number was less than five) were used for independent categorical variables. Bonferroni correction was made for subgroup analysis, and $p < 0.016$ was considered significant. The Mc Nemar test was used for dependent categorical variables. For the relationship between the treatment given with $EtCO_2$ and hospitalization discharge, the Mann-Whitney *U* test was used for independent two-group comparisons that did not show normal distribution, and the Kruskal Wallis test was used for multi-group comparisons. Student-t test was used for numerical two-group variables with normal distribution. $p < 0.05$ was considered significant.

Results

Of the 623 patients admitted to the ED with respiratory distress, 512 agreed to participate in the study (%82). Of these, 415 were excluded from the study for reasons explained in the method. The study was planned with 97 patients (Fig. 1). The average age of the patients was 70.9 ± 9.6 years, and 60.8% (n = 59) were male. 43.3% (n = 42) of the patients who admitted were ex-smokers. The most common comorbidities were hypertension (HT) with 76% (n = 74) and COPD with 58% (n = 57). 34% of the patients were hypercarbic at first presentation (0th minute, $PaCO_2$ at admission >45 mmHg). Descriptive data of the patients are presented in Table 1.

The results of $EtCO_2$ values between hospitalized and discharged patients, including measurements at admission, 60th and 120th minutes, are shown in Table 2. $EtCO_2$ value was statistically significantly higher in all measurements in hospitalized patients than in discharged patients.

Table 3 shows the results of the correlations between $EtCO_2$ and $PaCO_2$ and $PvCO_2$ measurements at the time of admission, the sixtieth and the 120th minute, in detail. When the $EtCO_2$ value was above 45 mmHg, a strong positive (r = 0.844 and r = 0.803) and significant relationship was found between $EtCO_2$ and $PaCO_2$ and $PvCO_2$ measurements (p < 0.001 for both).

Table 1 Descriptive data of patients with respiratory distress (n = 97).

Features	n (%)
Gender, Male	59 (60.8%)
Age, years (mean + SD)	70.9 ± 9.6
Initial arterial blood gas pH value	7.37 ± 0.08
[mean + SD (min–max)]	(7.081–7.57)
Treatment at admission	
Inhaler bronchodilator	45 (46.4%)
Diuretic	12 (12.4%)
Noninvasive mechanical ventilation	12 (12.4%)
(NIMV)	11 (11.3%)
Oxygen support only	12 (12.4%)
Inhaler + diuretic	5 (5.2%)
Diuretic + NIMV	0 (0.0%)
Invasive mechanic ventilation (IMV)	
Treatment at the first hour	
Inhaler bronchodilator	40 (41.2%)
Diuretic	15 (15.5%)
NIMV	15 (15.5%)
Oxygen support only	10 (10.3%)
Inhaler + diuretic	12 (12.4%)
Diuretic + NIMV	5 (5.2%)
IMV	0 (0.0%)
Treatment at the second hour	
Inhaler bronchodilator	35 (36.1%)
Diuretic	17 (17.5%)
NIMV	18 (18.5%)
Oxygen support only	12 (12.4%)
Inhaler + diuretic	11 (11.3%)
Diuretic + NIMV	4 (4.1%)
IMV	0 (0.0%)
Comorbidities[a]	
Heart failure	37 (38%)
Hypertension	74 (76%)
Chronic obstructive pulmonary	57 (58%)
disease	36 (37%)
Diabetes	13 (13%)
Coronary artery disease	11 (11%)
Chronic renal failure	7 (7%)
Lung malignancy	9 (9%)
Tuberculosis	4 (4%)
Other malignancies	1 (1%)
Interstitial lung disease	
Smoking	
Active drinker	
Ex-smoker	16 (16.5%)
Never drank	42 (43.3%)
	39 (40.2%)
Diagnosis of chronic hypercarbia	
($PaCO_2$ at admission > 45 mmHg)	
COPD exacerbation	33 (34.0%)
Heart failure	18 (18.6%)
Pneumonia	11 (11.3%)
Acute renal failure	2 (2.1%)
	2 (2.1%)

Table 1 (*Continued*)

Features	n (%)
Outcome	
Discharged	62 (63.9%)
Chest disease ward admission	23 (23.7%)
Cardiology ward admission	5 (5.2%)
Intensive care unit	7 (7.2%)

[a] Patients may have more than one comorbid condition.

When the $EtCO_2$ value was above 45 mmHg, a strong positive and significant relationship was found between $EtCO_2$ and $PaCO_2$ and $PvCO_2$ measurements ($r = 0.730$ and $r = 0.702$; $p < 0.001$ for both).

A strong positive and significant correlation was found between $PaCO_2$ and $PvCO_2$ measurement when the $EtCO_2$ value was below 35 mmHg ($r = 0.858$; $p < 0.001$). A strong positive and significant relationship was seen when $PaCO_2$ and $PvCO_2$ $EtCO_2$ values were between 35–45 mmHg ($r = 0.883$; $p < 0.001$). There was a strong positive and significant relationship between $PaCO_2$ and $PvCO_2$ measurement when the $EtCO_2$ value was above 45 ($r = 0.891$; $p < 0.001$).

In the last measurements at the 120th minute, a moderately positive and significant relationship was found between $EtCO_2$, $PaCO_2$ and $PvCO_2$ values ($r = 0.677$ and $r = 0.609$; $p < 0.001$ for both). When the $EtCO_2$ value was above 45 mmHg, a moderate positive and significant relationship was observed between $EtCO_2$ and $PaCO_2$ and $PvCO_2$ measurements ($r = 0.667$ and $r = 0.563$; $p < 0.001$ for both). When the $EtCO_2$ value was below 35 mmHg, a moderately positive and significant correlation was observed between $PaCO_2$ and $PvCO_2$ measurement ($r = 0.697$; $p < 0.001$). A strong positive and significant ($r = 0.791$; $p < 0.001$) relationship was detected between $PaCO_2$ and $PvCO_2$ measurements when the $EtCO_2$ value was between 35–45 mmHg. There was a strong positive and significant relationship between $PaCO_2$ and $PvCO_2$ measurement when the $EtCO_2$ value was above 45 mmHg ($r = 0.870$; $p < 0.001$).

We found a strong positive and significant relationship between $EtCO_2$ and $PaCO_2$ measurements at admission ($r = 0.820$; $p < 0.001$). The variance explained by the variables on each other is 67% (Fig. 2). We found a strong positive and significant relationship between 60th-minute $EtCO_2$ and $PaCO_2$ measurement ($r = 0.729$; $p < 0.001$). The variance explained by the variables on each other is 53% (Fig. 3). A strong positive and significant relationship existed between $PaCO_2$ and $PvCO_2$ measurement at the 60th minute ($r = 0.937$; $p < 0.001$). The variance explained by the variables on each other is 87% (Fig. 4). A moderately negative and significant relationship existed between $EtCO_2$ and SpO2measurement at admission ($r = -0.516$; $p < 0.001$). There was no significant relationship between $EtCO_2$ and SpO_2 measurement at the 60th minute and 120th minute ($p = 0.402$ and $p = 0.771$).

Discussion

Our study found a high correlation between $EtCO_2$ at admission (zero minutes) and $PaCO_2$ and $PvCO_2$ measurements ($r = 0.820$ and $r = 0.772$, respectively). We also found a high correlation between $PaCO_2$ and $PvCO_2$ ($r = 0.891$; $p < 0.001$). We found a moderately positive and significant relationship between $EtCO_2$ and $PaCO_2$ and $PvCO_2$ measurements when the $EtCO_2$ value was between 35–45 mmHg ($r = 0.621$ and $r = 0.657$, respectively; $p < 0.001$ for both). When the $EtCO_2$ value was above 45 mmHg, a strong positive and significant relationship was found between $EtCO_2$ and $PaCO_2$ and $PvCO_2$ measurements ($r = 0.844$ and $r = 0.803$, respectively; $p < 0.001$ for both). Apart from this, a strong correlation was observed between $PaCO_2$ and $PvCO_2$ for all measurements. These results showed that in triage patients presenting to the emergency department with respiratory distress, if the $EtCO_2$ value measured with a single blow is above 45 mmHg, the patient is considered hypercapnic, and treatment can be started early. Another important conclusion is that venous blood gas measurement is a strong alternative to arterial blood gas measurement, which is an excruciating procedure.

Arterial blood gas sampling in a patient presenting with respiratory distress is often challenging for both the patient and the physician. It may need to be repeated from time to time. Many clinical studies have been designed to increase patient comfort and identify new reliable methods. One of the alternative methods is $EtCO_2$ measurement. Healey et al. demonstrated a high correlation between $EtCO_2$ and $PaCO_2$ measured before and after withdrawal of assisted-controlled mechanical ventilation.[21] Plewa et al. found that the patients' $EtCO_2$ value obtained by the forced expiration model showed a high correlation with the $PaCO_2$ value. They also reported the negative predictive value of capnographic hypercapnia ($EtCO_2 > 45$ mmHg) in detecting arterial hypercapnia ($PaCO_2 > 45$ mmHg) as 95%.[22] Other studies conducted with non-intubated patients have also reported a high correlation.[1,18]

Measuring $EtCO_2$ in non-intubated patients has difficulties. Patient cooperation comes first among these difficulties. Although the initial panic of outpatients with respiratory distress is another difficulty for measuring $EtCO_2$ in the ED, it is easier than arterial blood gas sampling. Suzuki et al. their study of non-intubated patients followed up

Table 2 Comparison of end-tidal carbon dioxide ($EtCO_2$) values of patients with respiratory distress according to hospitalization status.

Parameters	All patients	Inpatients	Discharged	p value
$EtCO_2$ at admission	35 (30–45)	46.17 ± 15.235	33.95 ± 9.31	<0.001
$EtCO_2$ at the first hour	33 (28–41)	42.69 ± 14.784	32.90 ± 7.923	<0.001
$EtCO_2$ at the second hour	34 (29–41.25)	42.37 ± 15,923	34.06 ± 8.400	0.006

Values were shown as mean ± SD, or median (interquartile range). $p < 0.05$ was considered statistically significant.

Table 3 Correlation analyses of $EtCO_2$ and $PaCO_2$ and $PvCO_2$ measurements.

Zeroth minute		$EtCO_2$	$PaCO_2$	$PvCO_2$
$EtCO_2$ (mmHg)	*r*		0.820	0.772
	p		<0.001	<0.001
<35	*r*		–	–
	p		0.064	0.056
35–45	*r*		0.621	0.657
	p		<0.001	<0.001
>45	*r*		0.844	0.803
	p		<0.001	<0.001
$PaCO_2$ (mmHg)	*r*	0.820		0.891
	p	<0.001		<0.001
$PvCO_2$ (mmHg)	*r*	0.772	0.891	
	p	<0.001	<0.001	
60th minute				
$EtCO_2$	*r*		0.729	0.653
	p		<0.001	<0.001
<35	*r*		–	–
	p		0.341	0.361
35–45	*r*		0.635	0.551
	p		<0.001	<0.001
>45	*r*		0.730	0.702
	p		<0.001	<0.001
$PaCO_2$	*r*	0.729		0.937
	p	<0.001		<0.001
$PvCO_2$	*r*	0.653	0.937	
	p	<0.001	<0.001	
120th minute				
$EtCO_2$	*r*		0.677	0.609
	p		<0.001	<0.001
<35	*r*		–	–
	p		0.323	0.336
35–45	*r*		0.480	0.415
	p		<0.001	<0.001
>45	*r*		0.667	0.563
	p		<0.001	<0.001
$PaCO_2$	*r*	0.677		0.876
	p	<0.001		<0.001
$PvCO_2$	*r*	0.609	0.876	
	p	<0.001	<0.001	

$EtCO_2$: End-tidal carbon dioxide; $PaCO_2$: Partial pressure of arterial carbon dioxide; $PvCO_2$: Partial pressure of venous carbon dioxide. The correlation is significant at the $p < 0.05$ level; *r*: Spearman correlation coefficient.

due to respiratory diseases found a high positive correlation between $EtCO_2$ and $PaCO_2$ ($r = 0.88$; $p < 0.0001$).[23] Joe et al. in their study, it was stated that there was a significant correlation between $EtCO_2$ measurement and $PvCO_2$ in patients with chronic pulmonary disease and using oxygen ($r = 0.63$) and that the $PvCO_2$ level of the patients could be predicted with capnography, which is a noninvasive method.[24] These studies support our results. $EtCO_2$ is a more comfortable, faster, and easily reproducible alternative to arterial blood gas sampling when starting the initial treatment of patients presenting to the ED with respiratory distress.

Venous blood gas sampling is easy. Although it is an invasive procedure, it is not as difficult for the patient and physician to repeat as arterial blood gas sampling. Therefore, understanding the relationship between $PaCO_2$, $EtCO_2$ and PvCO2 was investigated.[25,26] However, studies in the literature contain a partial consensus. In a systematic review, only 22.5% of included studies identified a strong correlation between arterial and venous parameters.[25] Predictably, different results may occur depending on patient characteristics. In their methodological study with 20 patients with various diagnoses and complaints, Lumholdt et al. investigated the mathematical adaptability of peripheral venous blood gas values to arterial blood gas values. They stated that there was a mathematically predictable relationship between $PaCO_2$ and $PvCO_2$.[27] A study in non-intubated patients followed up for respiratory diseases indicated a positive correlation between $PaCO_2$ and $PvCO_2$ ($r = 0.81$; $p < 0.001$).[23] Our study showed a high correlation between

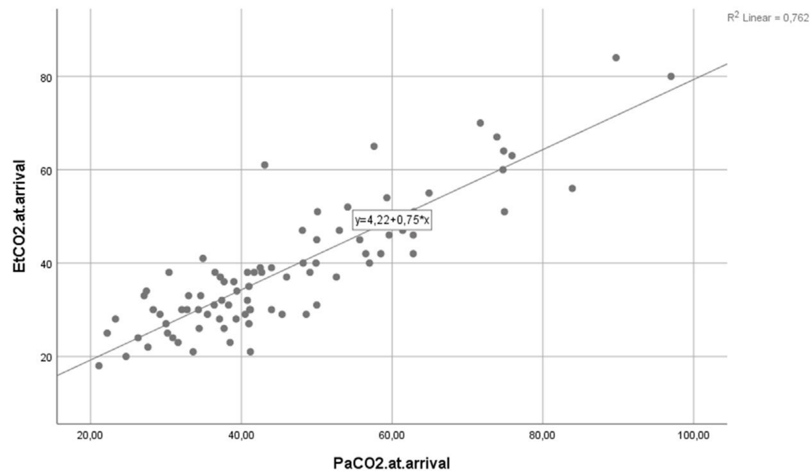

Figure 2 Linear correlation between end-tidal carbon dioxide ($EtCO_2$) and $PaCO_2$ levels at the admission.

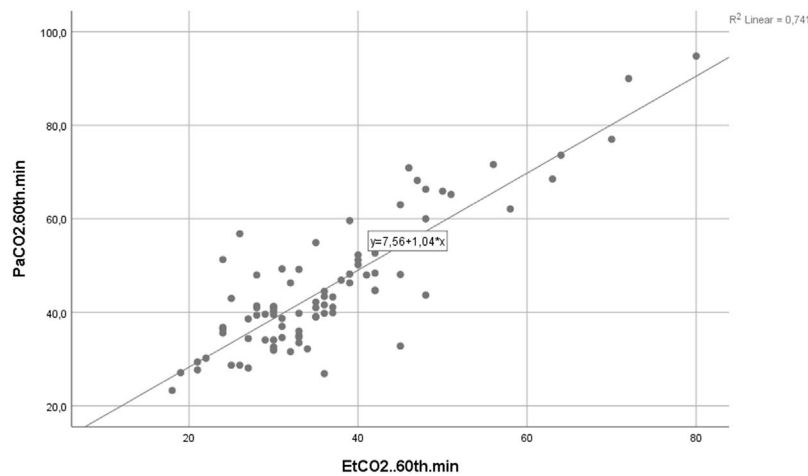

Figure 3 Linear correlation between end-tidal carbon dioxide ($EtCO_2$) and $PaCO_2$ levels at the time of 60th min.

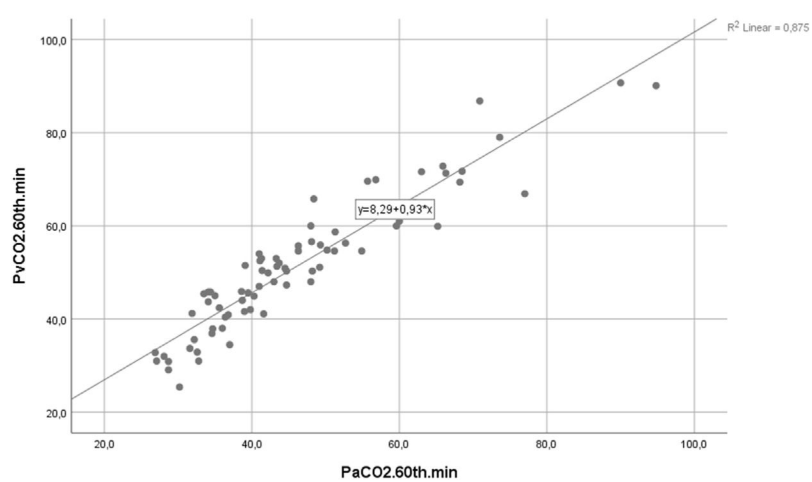

Figure 4 Linear correlation between $PaCO_2$ and $PvCO_2$ levels at the time of 60th min.

venous and arterial blood gas in terms of partial carbon dioxide pressure (pCO_2) in patients with respiratory distress from admission until the second hour of treatment. In light of all these findings, end-tidal carbon dioxide measurement seems to be an excellent alternative to arterial carbon dioxide measurement. In addition, venous carbon dioxide measurement is a good alternative in non-cooperative patients unsuitable for non-invasive end-tidal carbon dioxide measurement. The fact that it is less painful and can be taken from the vein simultaneously with many other blood tests makes venous carbon dioxide measurement more important.

Conflicting results have been revealed in the literature regarding whether capnography can replace $PaCO_2$ as a reliable tool in patients with acute respiratory distress.[2,3,28,29] In our study, $EtCO_2$ values of patients admitted with acute respiratory distress at admission and in the 1st and 2nd hours after treatment were associated with hospitalization. $EtCO_2$ measurements were higher in hospitalized patients compared to discharged patients.

The main limitation of this study is that it was conducted in a single center with a study group consisting of patients who presented to the ED of a tertiary university hospital. The low number of cases in the city where the study was conducted caused the number of patients included in this study to be limited. Second, we did not correct pCO_2 based on body temperature in any patient. Phan et al. noted that $EtCO_2$ correlated better with pCO_2 after temperature correction.[17] Third, the patient's respiratory rate was not recorded. When the respiratory rate increases, the dead space ratio increases, and the $EtCO_2$ level may decrease. Additionally, the capnometer may not detect $EtCO_2$ changes in case of a high respiratory rate.[24] The fourth limitation is that end tidal carbon dioxide measurement can only be performed in cooperative patients. Finally, conditions such as age, existing lung disease, and smoking may cause $EtCO_2$ values to change. Prediction ability decreases in the elderly and those with lung disease.[22] We did not perform subgroup analysis on the patients. Large-scale and multi-center studies in which subgroups are studied separately and necessary corrections are made according to the patient's vital values, such as respiratory rate and temperature, are needed to confirm this alternative diagnostic method.

Conclusion

The $EtCO_2$ value obtained from adding an insufflation device we produced to the capnograph and spontaneously inhaling patients with respiratory distress is a powerful alternative to arterial blood gas in the ED triage of patients and the first two hours of acute treatment. It has also been shown that venous blood gas may be a good alternative. In patients with acute respiratory distress (patients who can cooperate and whose hemodynamics have not yet deteriorated), this simple, noninvasive $EtCO_2$ measurement is also helpful in the early prediction of hospitalization decisions.

Author's contribution

KS, MCD, MB contributed to conception; KS, MCD, MB contributed to design; MCD, EŞ, MB contributed to supervision; KS, HG, AKFK, MT, EE contributed to data collection and processing; KS, MCD contributed to analysis and interpretation; KS, MCD, EŞ, MB contributed to literature review; KS, MCD, EŞ, MB contributed to writing; MCD, MB contributed to critical review.

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Declaration of interest

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Availability of data and materials

Submitted work is original and has not been published elsewhere in any language. Raw data are available for the editor on request.

Ethical statement

Ethics Committee approval was obtained from the local ethics committee (Date: March 20, 2023, Decision No: 2023/42).

Informed consent

Written consent was obtained from all patients.

Human rights

Authors declare that human rights were respected according to the Declaration of Helsinki.

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