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Araştırma

Is There an Alliance Between Body Mass Index and End-Tidal Carbon Dioxide Partial Pressure?

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ABSTRACT

Objective: *To determine the relation between body mass index and resting end-tidal carbon dioxide partial pressure in individuals with normal physical status is the primary goal of the present study.*

Material and Methods: *After obtaining written informed consents, the demographic data including age, gender, weight, height, body-mass index, and the American Society of Anesthesiologists score were recorded. In operating theatre, after 15 minutes of spontaneous ventilation in supine position wearing a modified face mask, the respiratory rate, and end-tidal carbon dioxide partial pressure measurements were obtained. The association between body-mass index, respiratory rate, and end-tidal carbon dioxide partial pressurewere analyzed using Pearson's correlation (r).*

Results: *A total of 56 patients were enrolled in the study. The Pearson correlation analysis showed no significance between body-mass index and end-tidal carbon dioxide partial pressure (r=0.148, p=0.275), respiratory rate (r=0.193, p=0.154), and end-tidal carbon dioxide partial pressure/respiratory rate (r=-0.079, p=0.565).*

Conclusion: *The present study showed that there was no relationship between body-mass index and end-tidal carbon dioxide partial pressure, end-tidal carbon dioxide partial pressure/respiratory rate or respiratory rate.*

Keywords: *carbon dioxide, body mass index, respiratory rate*

ÖZ

Vücut Kitle İndeksi ile Soluk Sonu Karbondioksit Basıncı Arasında İlişki Var mı?

Amaç: *Bu çalışmada amaç, vücut kitle indeksi ile dinlenme halindeki soluk sonu karbondioksit basıncı arasındaki ilişkinin tanımlanmasıdır.*

Gereç ve Yöntem: *Hastalardan yazılı onam alındıktan sonra, yaş, cinsiyet, ağırlık, boy, vücut kitle indeksi ve Amerikan Anestezistler Birliği değerini içeren demografik veriler kaydedildi. Operasyon odasında, 15 dk. sonunda modifiye bir yüz maskesiyle beraber spontan soluyan hastaların, solunum sayıları ve soluk sonu karbon dioksit basıncı değerleri kaydedildi. Vücut kitle indeksi, solunum sayısı ve soluk sonu karbon dioksit basıncı değerleri arasındaki ilişki Pearson korrelasyon analizi ile değerlendirildi.*

Bulgular: *Çalışmaya toplam 56 hasta dahil edildi. Pearson korelasyon analizi sonucunda, vücut kitle indeksi ile soluk sonu karbon dioksit basıncı (r=0.148, p=0.275), solunum sayısı (r=0.193, p=0.154), ve soluk sonu karbon dioksit basıncı / solunum sayısı (r=-0.079, p=0.565) arasında herhangi bir anlamlı ilişki saptanmadı.*

Sonuç: *Bu çalışma, vücut kitle indeksi ile soluk sonu karbon dioksit basıncı arasında herhangi bir ilişki olmadığını göstermiştir.*

Anahtar kelimeler: *karbon dioksit, vücut kitle indeksi, solunum sayısı*

INTRODUCTION

Carbon dioxide (CO_2) has a wide range of production sites including oceans, mammalian respiration, plant decay, and burning of fossil fuels [1]. Despite the diversity of formation, one other concern for the human is to elimate it from the body. Beside all single units of the body, muscle cells is the largest source of produced CO_2, which has to be removed from the body by exhalation of the lungs. To the current knowledge, the transportation and exchange of CO_2 are consisted of several mechanisms. In human body, CO_2 is being

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existed in the following three structural forms: dissolved, carbamate or bicarbonate. Approximately 5% of CO_2 is transported unchanged in the plasma. Carbon dioxide connects reversibly to hemoglobin to generate carbaminohemoglobin. In this composition, CO_2 binds to the amino groups on the polypeptide structure of hemoglobin and therewithal plasma proteins. The bound form of CO_2 contains 10% of the completely transported. Finally, the majority of CO_2 transfer is achieved by bicarbonate ions, which occurred by a cascade of reactions. After the entry of CO_2 into the erythrocytes in the tissue capillaries, a reaction with H_2O catalyzed by the enzyme carbonic anhydrase occurs to form carbonic acid. Therafter, carbonic acid rapidly decomposes to bicarbonate ions ($HCO3^-$), and hydrogen ions (H^+) [2].

End-tidal Carbon dioxide ($P_{ET}CO_2$) is accepted as the non-invasive estimation of arterial carbon dioxide tension. The synchronous follow-up by monitorization is the essential part of care in modern anesthetic practice, which provides information about ventilation status of the individual [3,4]. Since the respiratory failure is the crucial cause of morbidity, perioperative respiratory monitoring is the prior modality in anesthesia. In contrast to clinical anesthetic use, several studies have been conducted to define the relationship between cardiopulmonary exercise test response and carbon dioxide production [5-7]. One of these studies by Arena et al. [7] suggested that resting $P_{ET}CO_2$ can be a remarkable value to evaluate the condition of the patients with heart failure. In addition, the authors reported that there was a significant correlation existed between $P_{ET}CO_2$ and body-mass index (BMI) in patients with heart failure [7]. Therefore, we hypothesized that individuals in a normal physical health status with a higher body mass index tend to show a higher resting $P_{ET}CO_2$.

Overall, the present study aimed to determine the relation between body mass index and resting $P_{ET}CO_2$ in individuals with normal physical status.

MATERIAL and METHODS

After approval of the Gaziosmanpasa University Clinical Research Ethics Committee (15-KAEK-087), this prospective study was conducted from May 2015 to June 2015. Adult patients whose admitted to any surgical departments to undergo an operation under general anesthesia were invited to participate in the study. Ages between 18 and 40, and an American Society of Anesthesiologists (ASA) score of I or II were the inclusion criteria. Patients, with an ASA score of III or higher, undergoing an operation without tracheal intubation or planning to perform an abdominal surgery, or those with an upper airway pathology (maxillofacial fractures, tumours, etc.), the presence of an obstructive or restrictive pulmonary disease, and a history of smoking (tobacco and tobacco products), were excluded. After obtaining written informed consents, the demographic data including age, gender, weight, height, body-mass index, and the American Society of Anesthesiologists (ASA) score were recorded. In operating theatre, after 15 minutes of spontaneous ventilation in supine position wearing a modified face mask, the respiratory rate (RR), and $P_{ET}CO_2$ measurements were obtained by a monitor (Siemens Kion; Siemens, Solna, Sweden).

Assuming a 60% of proprotion rate on the relation between BMI and $P_{ET}CO_2$, with a two-sided type I error of 0.05, and a power of 0.80; 41 subjects were required to find a significant difference.

Statistical Analysis

Normality and variance were tested using the One-Sample Kolmogorov-Smirnov, skewness and kurtosis, and histograms for each variable. Quantitative data were presented as means and standard deviation, and qualitative data as frequency and percentage. Associations were performed by using the Pearson correlation coefficient (r). The comparisons were carried out by using Mann-Whitney U test. A multivariate regression modeling with linear backward stepwise method was used to find the possible predictors of $P_{ET}CO_2$. The backward stepwise method was applied to eliminate the suppressor effects, in which appear while a predictor has a significant effect only when another variable is held constant, and to restrict the risk of making a type II error, thereby missing a substantial predictor. This was so the variable with the highest p value, which has no significance at the 0.05 level, was excluded at each step. Analyses were completed by using the Statistical Package for Social Sciences (SPSS Inc., Chicago, IL) version 20.0 program. The statistical significance for all analyses was set at $p<0.05$.

RESULTS

A total of 56 patients were enrolled in the study. The demographic characteristics were presented in Table 1. The Pearson correlation analysis showed no significance between BMI and $P_{ET}CO_2$ (r=0.148, p=0.275), BMI and RR (r=0.193, p=0.154), and BMI and PET-CO_2/RR (r=-0.079, p=0.565; Table 2). A multivariate linear regression analysis using the backward stepwise elimination method of BMI, RR, weight, height, and ASA as candidate-independent variables and the $P_{ET}CO_2$ as dependent variable revealed that there was no significant predictors existed on $P_{ET}CO_2$ among the accepted candidate-independent variables [height (β=0.179, p=0.186); BMI (β=0.176, p=0.194); RR (β=-0.151, p=0.273); ASA (β=-0.083, p=0.547); weight (β=-0.831, p=0.588)].

Table 1. Demographic characteristics.

	(Mean±SD)	95% CI	Median
Weight (kg)	72,48±13,29	68,92-76,04	70
Height (m)	1,69±0,09	1,66-1,71	1,68
BMI (kg/m^2)	25,33±4,32	24,18-26,49	25,06
$P_{ET}CO_2$	34,92±3,59	1,66-35,89	35
ASA I/II	41/15	-	-

$P_{ET}CO_2$, end-tidal carbon dioxide partial pressure; ASA, American Society of Anesthesiologists; SD, standart deviation

Table 2. Correlation matrix.

	$P_{ET}CO_2$ r (p)	RR r (p)	$P_{ET}CO_2$/RR r (p)
BMI	0.148 (p=0.275)	0.193 (p=0.154)	-0.079 (p=0.565)

BMI, body mass index; $P_{ET}CO_2$, end-tidal carbon dioxide pressure; RR, respiratory rate; $P_{ET}CO_2$/RR, the ratio of end tidal carbon dioxide to respiratory rate; r, Pearson correlation coefficient.

DISCUSSION

The present study showed that there was no relation between BMI and $P_{ET}CO_2$. Additionally no association was existed between BMI and RR, and $P_{ET}CO_2$/RR. The exchange of oxygen and CO_2 between the body and the environment is performed by breathing-inhalation and exhalation. Respiratory centres in medulla oblangata and pons controls the inspiration and expiration activity cycle [8,9]. Briefly, two centres are existed in medulla oblangata; one for inspiration and one for expiration. The rhythmic action of inspiratory and expiratory neurons in these centres continuously stimulate the diaphragm and intercostal muscles resulting in a normal breathing rate between 12 and 18 per minute. Another two respiratory control centres are located in the pons; pneumataxic and apneustic. Both centre executing counter impacts on the inspiratory centre of the medulla. Pneumataxic centre adjusts the breathing rhythm avoiding over-inflation of the lungs, where apneustic centre induce the medullary inspiratory centre initiating to extend the inspiration period resulting in deeper and slower breaths. The requirements of the body determine the rate and depth of respiration. The respiratory centres in medulla oblangata and pons are influenced by several factors, in which the most significant ones are CO_2, oxygen and hyrogen ion levels in blood. Chemoreceptors located in the medulla have an absolute sensitivity to the changes in the quantity of these components. Carbon dioxide holds the most significant influence on respiration. Increased levels of CO_2 lead to a rise in the level of hydrogen ions, thus decreases the pH level of cerebro-spinal fluid. This effect results in an increase in the depth and frequency of respiration (hyperventilation) by the stimulation of central chemoreceptors. Hyperventilation stands until the full restoration of blood CO_2 levels [10].

In this context, Arena et al. [7] demonstrated a significant positive correlation between resting $P_{ET}CO_2$ and BMI in patients with heart failure and also emphasized that resting $P_{ET}CO_2$ may be an important predictor of cardiac-related events alone or in combination with a clinical and ventilatory expired gas measurement. Additionally, in a recent study by Shekharappa et al. [10] showed that heart rate, sistolic blood pressure and pulse pressure correlates with BMI in normal subjects, in which the association was partially described by Hirsch et al. as a 10% of rise in body weight is related with a decrease in parasympathetic activity resulted in a rise in mean heart rate.

Furthermore, the lung blood flow has a direct effect on $P_{ET}CO_2$, the reduce in flow causes a decrease in carbon dioxide elimination and $P_{ET}CO_2$. Several studies showed the relationship between resting $P_{ET}CO_2$ and cardiac output [11-13]. An experimental study conducted by Idris et al. [12] showed that $P_{ET}CO_2$ significantly correlated with alterations in cardiac index over a large range of blood flow rates. Another investigator, Wahba et al. [14] confirmed that $P_{ET}CO_2$ can be a predictor to determine shifts in cardiac index during open heart surgery. In relation, Matsumoto et al. [15] reported that $P_{ET}CO_2$ can be a new ventilatory abnormality marker which displays disrupted cardiac functions to exercise in patients with heart failure.

Moreover, a recent study by Arena et al. [16] reported that resting $P_{ET}CO_2$ provides information in a wide range of cardiac functional capacity, hence it can be a prognostic value in patients with heart failure. Mechanisms behind the decline in $P_{ET}CO_2$ in heart failure is obscured. A possible reason that progressive rise in physiologic dead space ventilation leads to a continuous decrease in $P_{ET}CO_2$ related with the severity of heart failure [17]. However, the decline in the resting $P_{ET}CO_2$ may point multifactorial items including reduced cardiac output, and decreased arterial partial pressure of carbon dioxide [16].

As mentioned above, the $P_{ET}CO_2$, strongly correlates with the cardiac function reserve in subjects with heart failure or undergoing surgery, and shows a trend to act together with BMI. All these studies focused on impaired physiological conditions including heart failure, obesity or surgery. In contrast, the present study demonstrated that no association was existed between BMI and $P_{ET}CO_2$, $P_{ET}CO_2$/RR or RR. Despite the distinct BMI values for each subject enrolled in the present study, $P_{ET}CO_2$ values were unallied. One explanation for this could be that $P_{ET}CO_2$ values in individuals with normal physical conditions may be controlled by a combination of several factors those have negative or positive impacts on the entire response of $P_{ET}CO_2$ to the micro-environmental changes in human body. Further investigations are required to uncover the mechanisms.

This study has limitations. First, the design of the study has a relatively small sample size. Second, minimal re-breathing of exhaled air may lead to a potential inaccuracy of $P_{ET}CO_2$ measurements during mask ventilation, however this study was not designed to define the performance of the settings. In addition, all subjects could be exposed to the same issue, which strictly restrict the interindividual variability in measurements.

In conclusion, resting $P_{ET}CO_2$ is a rapid with a low cost measurement which provides it a popularity in clinical practice. The present study revealed that there was no relationship between BMI and $P_{ET}CO_2$, $P_{ET}CO_2$/RR or RR. Our understanding on $P_{ET}CO_2$ has developed considerably since the outcomes of upcoming studies are reported.

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Conflict of interest
The authors have no conflicts of interest.

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