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Trabajo Original

Paciente crítico

Associations of body mass index and oxygen saturation with chronic obstructive pulmonary disease grade in patients

Asociación del índice de masa corporal y la saturación de oxígeno con el grado de enfermedad pulmonar obstructiva crónica en los pacientes

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Abstract

Introduction: we aimed to investigate the associations of body mass index (BMI) and oxygen saturation with chronic obstructive pulmonary disease (COPD) grade in COPD patients.

Materials and methods: the clinical data of 105 COPD patients admitted to and treated in our hospital during January 2021 and January 2022 were acquired for a retrospective analysis, and grade 1 group [$n = 15$, subjects presenting forced expiratory volume in one second (FEV1) ≥ 80 % of the predicted value], grade 2 group ($n = 32$, those with FEV1 ≥ 50 % and < 80 % of the predicted value), grade 3 group ($n = 34$, those with FEV1 ≥ 30 % and < 50 % of the predicted value), and grade 4 group ($n = 24$, those with FEV1 < 30 % of the predicted value or with FEV1 < 50 % of the predicted value and concomitant respiratory failure) were set up based on COPD grade.

Results and conclusion: the BMI of the 105 patients was 20.39 ± 3.31 kg/m² on average, and it showed differences of statistical significance regarding the subjects with varying COPD grades ($p < 0.05$). The oxygen saturation was 89.98 ± 4.04 on average in the 105 patients, and it also displayed statistically significant differences among patients with different grades of COPD ($p < 0.05$). According to pairwise comparison, grade 1 group exhibited the highest oxygen saturation, followed by grade 2, 3, and 4 groups in turn ($p < 0.05$). Both BMI and oxygen saturation had negative correlations with COPD grade ($p < 0.05$). In COPD patients, COPD grade is negatively correlated with BMI and oxygen saturation.

Keywords:

Chronic obstructive pulmonary disease. Body mass index. Grade. Oxygen saturation.

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Resumen

Introducción: nuestro objetivo fue investigar las asociaciones del índice de masa corporal (IMC) y la saturación de oxígeno con el grado de enfermedad pulmonar obstructiva crónica EPOC en pacientes con EPOC.

Materiales y métodos: se recogieron para un análisis retrospectivo los datos clínicos de 105 pacientes con EPOC ingresados y tratados en nuestro hospital durante los meses de enero de 2021 y enero de 2022, grupo grado 1 [$n = 15$, sujetos con volumen espiratorio forzado en un segundo (FEV1) ≥ 80 % del valor previsto], grupo grado 2 ($n = 32$, aquellos con FEV1 ≥ 50 % y < 80 % del valor previsto), grupo grado 3 ($n = 34$, aquellos con FEV1 ≥ 30 % y < 50 % del valor previsto) y grupo grado 4 ($n = 24$, aquellos con FEV1 < 30 % del valor predicho o con FEV1 < 50 % del valor predicho e insuficiencia respiratoria concomitante) se configuraron en función del grado de EPOC.

Resultados y conclusión: el IMC de los 105 pacientes fue 20,39 ± 3,31 kg/m² en promedio, y mostró diferencias de significación estadística con respecto a los sujetos con grados variables de EPOC ($p < 0,05$). La saturación de oxígeno fue 89,98 ± 4,04 de media en los 105 pacientes y también mostró diferencias estadísticamente significativas entre los pacientes con diferentes grados de EPOC ($p < 0,05$). De acuerdo con la comparación de pares, el grupo de grado 1 presentó la mayor saturación de oxígeno, seguido por los grupos de grado 2, 3 y 4 a su vez ($p < 0,05$). Tanto el índice de masa corporal como la saturación de oxígeno tuvieron correlaciones negativas con el grado de EPOC ($p < 0,05$). En pacientes con EPOC, el grado de EPOC está negativamente correlacionado con el índice de masa corporal y la saturación de oxígeno.

Palabras clave:

Enfermedad pulmonar obstructiva crónica. Índice de masa corporal. Grado. Saturación de oxígeno.

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) refers to a preventable and remediable morbid state, with the feature of airway limitation, which, however, cannot be completely reversed. Usually, airway limitation is progressive and has an association with the aberrant inflammatory reactions in the lungs to toxic particles or gases, which is mainly attributed to smoking. COPD acts as the primary cause of morbidity and disability in the world. The mortality rate and prevalence rate of COPD rose by nearly 11 % and 44 %, respectively, from 1990 to 2015 (1). COPD manifests pulmonary elastic recoil loss and/or airway stenosis-induced airway limitation (2). COPD not only has an effect upon pulmonary function but also leads to malnutrition, weight loss, peripheral muscle dysfunction and other severe systemic consequences (3). Such severe systemic consequences are also considered as important clinical characteristics of COPD since they have been found to easily result in exercise intolerance, decreased health status and increased mortality rate along with the deepening of the research on COPD (4). Besides, with pulmonary function deterioration plus disease progression, the risks of alveolar hypoxia and hypoxemia induced therefrom are on the rise. COPD subjects with oxygen saturation levels below 90 % are more likely to suffer from severe dyspnea, impaired quality of life, raised risks of cardiovascular disease and death, and decreased exercise tolerance (5,6). In COPD patients, the low body weight shows a relation to increased mortality rate, and it is independent of pulmonary function (7).

In the present study, the correlations of oxygen saturation and body mass index (BMI) with COPD severity were determined. The correlations between COPD grade and the two indicators can serve as a supplementary index for the disease severity, conducive to the cognition and management of COPD.

METHODS

GENERAL DATA

Totally 105 COPD sufferers, who were hospitalized for treatment from January 2021 to January 2022 were enrolled for retrospective analysis of clinical data. The inclusion criteria involved: 1) patients meeting the clinical diagnostic criteria for COPD (8); 2) those with an age of ≥ 18 years old, and 3) those possessing completely recorded clinical data. The exclusion criteria included 1) patients with acute COPD exacerbation within 4 weeks before enrollment; 2) those undergoing oral steroid therapy or home oxygen therapy, or 3) those suffering active pulmonary tuberculosis, heart failure or malignant tumor. The 105 COPD patients were assigned to grade 1 group [$n = 15$, patients whose forced expiratory volume in one second (FEV1) was more than or equal to 80 % of the predicted value], grade 2 group ($n = 32$, patients whose FEV1 was more than or equal to 50 % and less than 80 % of the predicted value), grade 3 group ($n = 34$, patients whose FEV1 was more than or equal to 30 % and less than 50 % of the predicted value), and grade 4 group ($n = 24$, patients whose FEV1 was more than or equal to 30 % of the predicted value or those with FEV1 below 50 % of the predicted value and suffered from respiratory failure) based on COPD grade. The present study was implemented as per the Declaration of Helsinki.

MEASUREMENT OF BMI

The body weight and height of patients were measured by a specially assigned person using 813 digital weight scale (Seca, Germany) and 217 portable stadiometer (Seca, Germany) at admission, and then BMI was obtained from the formula as follows: BMI = body weight / height^2 (kg/m^2).

OXYGEN SATURATION

The oxygen saturation of patients was measured by a fingertip pulse oximeter (MD300C, Beijing Choice Electronic Tech Co., Ltd., China) after patients did not inhale oxygen for 30 min.

STATISTICAL ANALYSIS

The SPSS 23.0 software was adopted for data analysis. The continuous variables such as age, BMI and oxygen saturation

were expressed by mean ± standard deviation ($x \pm s$) and subjected to normality test and homogeneity test for variance. The *t*-test and analysis of variance were adopted to assess the significant differences in the aforementioned variables among groups. The classified variables including gender, education level, occupation and marital status were expressed as percentage [*n* (%)], and their significant differences among groups were evaluated by the chi-square test. Pearson's correlation analysis was employed to probe into the correlations involving COPD grade, BMI and oxygen saturation. The difference of statistical significance was denoted with $p < 0.05$.

RESULTS

BASELINE DATA

Among the 105 COPD patients enrolled in the present study, 75 were males and 30 were females, with an age of 47-80 years and 62.36 ± 6.54 years on average. As to the education level, 55 cases of primary school or below, 36 cases of junior high school, and 14 cases of senior high school or above were recorded. In terms of occupation, there were 21, 61 and 23 cases of light, moderate and heavy work, respectively. For marital status, 92 patients were married, 11 patients were widowed, 1 patient was unmarried, and 1 patient was divorced. No statistically significant differences were found in age and gender distribution among grade 1, 2, 3 and 4 groups ($p > 0.05$) (Table I).

BMI OF SUBJECTS PRESENTING DIVERSE COPD GRADES

The mean BMI of the 105 patients was 20.39 ± 3.31 kg/m². For the patients with varied COPD grades, the BMI was statistically significantly different ($p < 0.05$). The results of pairwise comparison uncovered that the BMI was the largest in grade 1 group, followed by that in grade 2, 3, and 4 groups in turn ($p < 0.05$) (Table II).

OXYGEN SATURATION IN PATIENTS DISPLAYING DIVERSIFIED COPD GRADES

The average oxygen saturation was 89.98 ± 4.04 in the 105 patients. The difference in oxygen saturation among patients with varying COPD grades was statistically significant ($p < 0.05$). It was found by pairwise comparison that grade 1 group manifested the highest oxygen saturation, followed by grade 2, 3, and 4 groups in turn ($p < 0.05$) (Table III).

CORRELATIONS OF COPD GRADE WITH OXYGEN SATURATION PLUS BMI

The Pearson correlation analysis was performed with BMI and oxygen saturation as the dependent variables and COPD grade as the independent variable. The results revealed that both BMI and oxygen saturation were negatively correlated with COPD grade ($r = -0.617$ and -0.926, $p < 0.001$) (Table IV).

Table I. Baseline data [*n* (%), ($x \pm s$)]

Group	*n*	Age (year)	Gender	
			Male	Female
Grade 1 group	15	61.45 ± 4.28	11 (73.33 %)	4 (26.67 %)
Grade 2 group	32	61.96 ± 4.32	22 (68.75 %)	10 (31.25 %)
Grade 3 group	34	62.78 ± 5.89	23 (67.65 %)	11 (32.35 %)
Grade 4 group	24	62.11 ± 5.69	19 (79.17 %)	5 (20.83 %)
F/χ^2		0.270	1.081	
p		0.845	0.781	

Table II. BMI in patients with different COPD grades ($x \pm s$)

Group	*n*	BMI (kg/m²)
Grade 1 group	15	24.52 ± 3.37^{abc}
Grade 2 group	32	21.15 ± 2.64^{bc}
Grade 3 group	34	19.82 ± 2.68^{c}
Grade 4 group	24	17.61 ± 1.59
F/χ^2		23.689
p		< 0.001

[a]$p < 0.05$ vs. *Grade 2 group*, [b]$p < 0.05$ vs. *Grade 3 group*, [c]$p < 0.05$ vs. *Grade 4 group*.

Table III. Oxygen saturation in patients with different COPD grades ($x \pm s$)

Group	*n*	Oxygen saturation (%)
Grade 1 group	15	95.89 ± 1.34^{abc}
Grade 2 group	32	92.48 ± 1.86^{bc}
Grade 3 group	34	88.71 ± 1.47^{c}
Grade 4 group	24	84.76 ± 1.64
F/χ^2		181.854
p		< 0.001

[a]p < 0.05 vs. *grade 2 group, [b]p < 0.05* vs. *grade 3 group, [c]p < 0.05* vs. *grade 4 group.*

Table IV. Pearson's correlation analysis of BMI and oxygen saturation with COPD grade

Variable	Correlation coefficient (r)	*p*
BMI vs. COPD grade	-0.617	< 0.001
Oxygen saturation vs. COPD grade	-0.926	< 0.001

DISCUSSION

As a common chronic progressive disease in the elderly, COPD displays rapidly elevated morbidity and mortality rates in recent years. In addition, COPD has a high risk of disability, severely affecting the physical and mental health as well as the quality of life of patients. Currently, there are controversies about the pathogenesis of COPD, and exploring biomarkers related to the progression of COPD is of vital significance.

In case of COPD, the inflammatory lesions are distributed in all levels of trachea in the lungs, which, however, can also lead to systemic diseases, with malnutrition and skeletal muscle dysfunction as the most common ones. Some researchers have noticed that COPD patients often experience different degrees of body weight loss, and low body weight is observed in 24 % of patients in the stable stage and 54-60 % of patients in the acute exacerbation stage (9). BMI, a crucial physiological indicator to assess the nutritional status of human body, is a neutral and reliable statistical index, which balances the interaction between height and body weight when determining overweight and underweight. The identification of different metabolic phenotypes in COPD patients is essential for assessing nutritional risk profiles. Two well-characterized phenotypes are the emphysematous "pink puffer" with a BMI and the chronic bronchitis "blue bloater" with a high BMI (10). Nutritional interventions are particularly beneficial for undernourished patients, especially when combined with exercise programs (11).

In this study, the increase in COPD severity had an association with the prominently reduced average oxygen saturation ($p < 0.01$), in line with the findings of Kumar et al. (12), that is, the mean oxygen saturation gradually declined with the increase in COPD severity. One possible explanation for such a decline is that the ventilation/perfusion mismatch is gradually aggravated as the disease progresses (13). Another vital factor for hypoxemia in COPD patients is the change of ventilation control (14). Similarly, pulmonary function will deteriorate with the progression of the disease, which increases the risks of alveolar hypoxia and hypoxemia, resulting in decreased oxygen saturation. As COPD progresses, hypoxemia and decreased oxygen saturation serve as important manifestations since they will give rise to decreased quality of life, neurocognitive function and exercise tolerance, as well as elevated risks of aggravation along with death (15). Therefore, there is a negative correlation between COPD grade and oxygen saturation, and thus the latter can become a marker hinting COPD severity, particularly in cases that the resources are limited and pulmonary function tests are unavailable.

In the present study, the subjects having grade 4 COPD exhibited the smallest BMI, while those with grade 1 COPD displayed the largest BMI, similar to the study conclusions of Schols et al. (16), that is, weight loss occurred in about 50 % of COPD participants. Besides, research performed by Gupta et al. (17) in India denoted that the malnutrition degree dropped in grade 1 COPD sufferers compared with that in grade 4 COPD sufferers (25 % *vs.* 80 %). The present study yielded consistent results with previous studies. However, a study carried out by Cochrane et al. (18) reported that in 103 COPD patients in Britain, the change in COPD severity had no impact on the BMI of patients. In this study, BMI of COPD patients was found to have a negative correlation with COPD grade, and it was obviously affected by the change of the illness. This is inconsistent with the conclusion of the previous study, which may be ascribed to the disparities between the two countries in terms of dietary intake patterns besides geographical distribution. In clinical practice, nutritional management should be strengthened for severe COPD patients because low BMI may be a vital and independent risk factor for the death and attack of such patients.

It was uncovered in the present study that the BMI of subjects decreased continuously as the COPD grade rose, similar to the findings reported by Steuten et al. (19). The nutritional status of COPD patients deteriorates with the aggravation of the disease. Likewise, Montes de Oca et al. discovered that patients with a higher BMI presented lower COPD grades, and they forecast the potential role of low BMI as an indicator for mortality rate of COPD patients (20).

Moreover, many cross-sectional or cohort studies have also proved the association between COPD and low BMI. For instance, as manifested by the PLATINO study in Latin America, COPD patients were composed of higher proportions of underweight (< 20 kg/m^2) and normal weight (20-24.9 kg/m^2) subjects but lower proportions of overweight and obese (≥ 25 kg/m^2) subjects by contrast to subjects without COPD (18). In addition, it that low BMI was reported to serve as an independent risk factor for the death of COPD patients (21), and it exhibits the strongest correlation in patients having serious COPD. Patients presenting a higher BODE (BMI [B], airflow obstruction [O], dyspnea [D] and exercise capacity [E]) score suffer a raised death risk. For every

1-point increase in BODE score, the hazard ratios of all-cause death and respiratory death are 1.34 [95 % confidence interval (95 % CI): 1.26-1.42, $p < 0.05$] and 1.62 (95 % CI: 1.48-1.77, $p < 0.05$), respectively (22).

Malnutrition in COPD patients, reflected in an BMI indicating underweight, has a relationship with the imbalance between energy intake and energy consumption. Food intake is reduced in COPD patients since they have such symptoms as dyspnea, early satiety, fatigue, and loss of appetite after meals (23). Besides, energy consumption increases because of enhanced work of breathing, systemic inflammation, as well as thermogenic action of bronchodilators. Additionally, the weight loss of COPD patients is also possibly attributed to the role of corticosteroids in negatively affecting skeletal muscle function. From the microscopic perspective, the increased COPD severity has a relation to muscle fiber atrophy, muscle fiber change and mitochondrial function loss (24). Based on the aforementioned results, COPD damages the cellular metabolic function, thereby inducing weight loss that leads to a low BMI. The low BMI has a correlation with the mortality rate of COPD patients.

The progression of COPD is closely linked to a decrease in BMI, particularly in advanced stages of the disease. As COPD severity increases, patients often experience a negative energy balance due to elevated resting energy expenditure and reduced caloric intake. This imbalance is driven by the increased work of breathing, systemic inflammation, and altered nutrient metabolism. Additionally, chronic inflammation and elevated levels of pro-inflammatory cytokines, such as TNF-α and IL-6, contribute to skeletal muscle wasting and reduced appetite, exacerbating weight loss and decreasing BMI (25). The loss of muscle mass is a critical factor in the decline of BMI in COPD patients, as muscle atrophy is a direct consequence of oxidative stress, hypoxia, and impaired protein metabolism (26). Addressing these metabolic alterations through nutritional interventions and personalized treatment strategies is crucial for improving the management of COPD and mitigating the risk of severe weight loss in affected individuals (27).

The present study has some limitations. For example, the sample size was small, so the effect of a moderate sample size should be taken into account when interpreting results. Furthermore, BMI may fail to function as an ideal tool for body weight measurement of all COPD subjects given that some COPD patients may suffer from edema due to pulmonary arterial hypertension, so the results of these patients should be discreetly interpreted.

In conclusion, in COPD patients, the disease grade is negatively correlated with BMI plus oxygen saturation, i.e., the BMI and oxygen saturation decline with the increase in COPD grade. This finding may be conducive to the prediction of the severity of the illness in such patients, rendering some reference for clinic practice.

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