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Research Article

Analysis of Clinical Characteristics of Imaging Phenotypes in Patients with AECOPD

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Abstract

Objective: To analyze the clinical characteristics of imaging phenotypes in patients with AECOPD.

Methods: 180 patients with AECOPD who received treatment in the out-patient and inpatient department of Respiratory and Critical Care Medicine of Yinchuan First People's Hospital from January to August 2021,all patients received chest HRCT and filled in CAT, mMRC, HADS and PSQI questionnaires, according to the degree of emphysema and the thickness of bronchial tube wall on HRCT, they were divided into three groups: tracheitis type (A), emphysema type (E) and mixed type (M), to assess the difference between three groups.

Results: The BMI of group E and M was significantly lower than group A, but the smoking index was significantly higher than group A. The mMRC and CAT scores of group A and E were lower than group M, and there was no significant difference in HADS scores among the three groups, but the sleep quality of group M was the worst.

Conclusion: The prognosis for the group A was the most favorable. The symptoms of the group M were more pronounced, with a significant impact on daily life due to COPD, the extent of emphysema and thickening of the bronchial wall were particularly severe.

***Keywords**: AECOPD; Imaging Phenotype; Clinical Characteristics*

Introduction

Acute exacerbation of chronic obstructive pulmonary disease (AECOPD) is a highly variable condition characterized by heightened respiratory responsiveness, systemic inflammation, and physiological changes, all of which significantly impact patients adversely. The heterogeneity of COPD is manifested in various aspects including clinical manifestations, pathogenesis, and imaging, collectively referred to as clinical phenotypes [1]. Investigating the diverse clinical phenotypes of COPD and administering precise treatments are crucial for effectively preventing acute exacerbations of COPD. This study analyzes chest CT imaging findings in 180 patients with AECOPD, examines the clinical characteristics associated with different imaging phenotypes of AECOPD patients, and offers new insights for the individualized and targeted prevention and treatment of AECOPD.

Materials and Methods

Research object

The study included 180 patients with AECOPD who were treated and admitted to the Department of Respiratory and Critical Care Medicine in the First People's Hospital of Yinchuan from January to August 2021.

Inclusion criteria

① Meet the COPD diagnostic criteria in the 2021 GOLD Guidelines [2]; ② Have a typical respiratory history; ③ Pulmonary function index: ratio of forced expiratory volume to forced vital capacity (FEV1/FVC) in one second after inhalation of bronchodilator < 70%; ④ Acute exacerbation of respiratory symptoms, manifested as increased dyspnea, cough, increased expectoration, necessitates changes in medication [3].

Exclusion criteria

① Patients with bronchial asthma, bronchiectasis, lung cancer and other malignant tumors; ② Patients with chronic inflammatory diseases of other systems; ③ Patients treated with systemic glucocorticoids and immunosuppressants within the last month; ④ Patients with lower extremity venous thrombosis and pulmonary embolism.

Imaging phenotyping criteria and grouping

All subjects underwent chest high-resolution CT (HRCT) scanning with Siemens 64-slice spiral CT scanner, without the knowledge of clinical data, two radiologists selected three anatomical levels representing the upper, middle and lower lung fields of both lungs to observe and evaluate the degree of emphysema and the thickness of bronchial tube wall: 1 cm near the upper margin of the aortic arch, 1 cm below the level of the carina, and 3 cm above the right diaphragm represent the bilateral upper, middle and lower lung fields, respectively [4].

Evaluation method of emphysema degree: The percentage of low-density attenuation area (LAA) in the above three layers was evaluated by subjective semi-quantitative measurement, and the CT threshold was selected as -950HU [5]. LAA% was scored according to the three pulmonary fields on both sides: LAA < 5%, 0 score; 5% ≤ LAA < 25%, 1 score; 25% ≤ LAA < 50%, 2 points; 50% ≤ LAA < 75%, 3 points; LAA ≥ 75%, 4 points. Rating according to the total score: Total score 0, 0 level; Total score 1 - 3, Level 1; Total score 4 - 6, level 2; Total score 7 - 9, level 3; Total score 10 - 12, level 4 [6,7].

Evaluation method of bronchial tube wall thickness: According to the ratio of measured bronchial tube wall thickness (T) to the diameter of adjacent pulmonary artery (PA), the grade was 0, with T/PA < 30%; Level 1, 30% ≤ T/PA < 50%; Level 2, T/PA ≥ 50% [8].

According to Fujimoto's research method [9], 180 AECOPD patients were divided into three groups of imaging phenotypes: bronchitis type (A), emphysema type E and mixed type M according to LAA and T on HRCT. The specific classification criteria are shown in table 1.

Phenotypic classification	LAA classification	Thickening of bronchial tube wall
Type A	≤ Level 1	Merger/No
Type E	≥ Level 2	No
Type M	≥ Level 2	≥ Level 1

Table 1: *Imaging phenotyping criteria for COPD patients.*

Methods

Clinical assessment criteria

CAT scale

Clinical symptoms and health status of AECOPD were evaluated and quantized, including respiratory symptoms such as cough, phlegm, chest tightness, wheezing, and non-respiratory symptoms such as daily activity restriction, confidence in going out, sleep status, and energy, with a total score of 40. The higher the total score, the more significant the impact on patients [10,11].

mMRC scale

The 5-level test scale is used to quantify the relationship between patients' dyspnea and daily activity ability [11,12].

HADS scale

A total of 14 questions were used to assess the psychological state of the patients, among which 7 questions were used to assess the degree of depression and the other 7 questions were used to assess the degree of anxiety. 8 - 10, suspicious symptoms; A score of 11 - 21 indicates the presence of symptoms [13].

PSQI scale

There are 19 items, including 7 dimensions. Each item is scored on a scale of 0-3, and the total score is 21 points, which is used to evaluate the sleep quality of patients. The higher the score, the worse the sleep quality [14].

Statistical methods

SPSS 22.0 was used for data analysis and processing, and the measurement data were expressed as $\bar{x} \pm s$. T-test was used for the comparison of the mean of two samples. One-way analysis of variance was used to compare the means of multiple samples. Counting data were tested by χ^2, and $P < 0.05$ indicated statistical difference.

Results

Comparison of general data among the three groups

Among the 180 subjects, there were 71 cases (39.4%) in type A group, 48 cases (26.7%) in type E group and 61 cases (33.9%) in type M group. The BMI of type E and M groups was lower than type A group, and the smoking index was higher than type A group, with statistical differences ($P < 0.05$). There was no difference in age and sex among the three groups ($P > 0.05$) (See table 2).

Group	N (Case)	Age (Years)	Gender		Smoking Index (Number of cigarettes smoked/day × year)	BMI (kg·cm^{-2})
			Male	Female		
Type A	71	69.03 ± 11.04	44	27	247.21 ± 253.08*	28.23 ± 3.49**
Type E	48	72.11 ± 15.26	30	18	871.06 ± 471.62	21.98 ± 0.63
Type M	61	74.14 ± 11.31	50	11	616.19 ± 188.01	21.88 ± 2.19
c^2/F	-	0.670	1.082		6.394	9.523
P	-	0.701	0.624		0.019	0.006

Table 2: *Comparison of general data between the three groups.*

*Note: * and E type and M type groups were statistically significant, P < 0.05; **Compared with E type group and M type group, the difference was statistically significant, P < 0.05.*

Comparison of clinical conditions among the three groups

Compared with the A and E groups, the M-type patients had more dyspnea, worse sleep and quality of life ($P < 0.05$). Compared with E group, patients with type A and M group had more sputum ($P = 0.028$). There was no significant difference in the degree of cough, anxiety and depression among the three groups ($P > 0.05$). Chi-square test analysis showed that the severity of patients' disease was correlated with imaging phenotype ($P < 0.05$) (See table 3).

		Type A	Type E	Type M	c^2	P
Dyspnea					45.481	0.001
	Level 0	12.5%	10.8%	0.0%		
	Level 1	24.1%	40.7%	13.5%		
	Level 2	39.9%	39.3%	29.1%		
	Level 3	11.9%	9.2%	43.6%		
	Level 4	11.6%	0.0%	13.8%		
HADS					3.018	0.481
	Asymptomatic	38.9%	55.8%	13.8%		
	Suspicious symptoms	49.6%	27.6%	59.3%		
	Symptomatic	11.5%	16.6%	26.9%		
PSQI					20.184	0.001
	Excellent	11.8%	19.2%	13.2%		
	Satisfactory	25.1%	39.5%	14.9%		
	Average	47.9%	25.9%	27.4%		
	Poor	15.2%	15.4%	44.5%		
CAT					29.592	0.000
	Minor	13.1%	74.8%	13.9%		
	Moderate	47.0%	11.6%	11.8%		
	Serious	26.4%	10.5%	51.2%		
	Very serious	13.5%	3.1%	23.1%		

Table 3: *Correlation analysis between imaging phenotypes and severity of disease.*

Discussion and Conclusion

COPD is a group of multi-system heterogeneous diseases, and COPD can be divided into different phenotypes according to heterogeneity. According to the Japanese Fujimoto [9] standard, 180 AECOPD patients were divided into three groups: A, E and M, accounted for 39.4%, 26.7% and 33.9% respectively. Further analysis of the clinical characteristics of three groups of patients with radiographic phenotype, found group A had significantly higher BMI than group E and M ($P = 0.008$), suggested that type A set of nutrition and prognosis is better than type E and M. Studies have found that COPD patients with low BMI have more severe symptoms, obvious carbon dioxide retention and hypoxia, worse lung function, and more severe respiratory obstruction during the acute exacerbation period, indicating that BMI reflects the severity of COPD patients [15-17]. Our previous studies have found that high BMI is a protective factor for COPD patients with sarcopenia [18], and these studies have clarified that BMI has an important impact on the progression and prognosis of COPD disease. Although BMI is an important indicator of nutritional status in patients with COPD, it does not fully reflect the characteristics of changes

in body composition such as muscle mass and fat volume, which have been shown to be important prognostic indicators of death in patients with COPD. Foreign studies have found that COPD patients with low BMI have better exercise ability than those with low FFMI in the normal or high fat-free body mass index (FFMI) group, while patients with low FFMI, regardless of BMI, have lower 6-minute walking distance and health-related quality of life [19]. These results indicate that BMI and FFMI provide complementary information for body composition assessment, and both should be fully valued to further assess the function of daily living in COPD patients and contribute to disease risk stratification.

In this study, the smoking index was significantly higher in the group E and M compared to the group A, along with a higher LAA grade, indicating that smoking contributes to the development of emphysema. Cigarettes contain harmful substances that cause airway cell damage, reduce ciliary movement, increase oxygen free radicals, and trigger the release of large amounts of proteases by neutrophils, resulting in the destruction of pulmonary elastin fibers and emphysema. According to this imaging phenotype classification standard, it was also found that the elevated smoking index affected emphysema earlier than bronchial wall thickening, suggesting that early changes in cigarette smoke stimulation primarily involve increased production or activation of protease enzymes, later accompanied by cytokine or chemokine-mediated activation of fibroblasts and fibrosis changes in lung tissue. Therefore, the poor prognosis of the group E and M may be associated with the inflammatory cascade and the vicious cycle of nutritional immunity triggered by tobacco smoke, strongly advocating for more stringent smoking cessation advice. Comparing with this imaging phenotype classification standard, the group M exhibited the most severe emphysema and bronchial wall thickening, indicating a significant increase in the elastin-mediated autoimmune response under cigarette smoke stimulation, leading to more severe damage to the body. Further genomic sequence analysis of this group is essential, and for these patients, considering matrix metalloproteinase-12, reactive protein peptides, or interleukin-17A as potential new therapeutic targets may be appropriate when conventional treatments fail.

Utilizing scales to assess clinical symptoms provides a direct indication of the disease's severity. In this study, the group M exhibited higher mMRC and CAT scores compared to the group A and E, suggesting that the group M had a greater number of symptoms with the most severe breathing difficulties, and their daily living status was significantly impacted by COPD. There were no significant differences in anxiety and depression levels among the groups; however, the group M demonstrated the poorest sleep quality. Sleep disorders are prevalent among COPD patients, and research indicates that poor sleep quality is associated with the risk of acute exacerbations of COPD [20,21]. Consequently, the treatment of sleep disorders should be a key focus in the comprehensive management of COPD.

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