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Etiological Characteristics and Risk Factors of Chronic Obstructive Pulmonary Disease Combined with Infection

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The distribution characteristics of pathogenic bacteria and the related health risk of pulmonary infection in patients with chronic obstructive pulmonary disease (COPD) were retrospectively analyzed to develop targeted measures to enhance patient prognosis. A retrospective analysis was conducted on the clinical data of 108 patients with COPD complicated with pulmonary infection and 108 patients without pulmonary infection. Analyze the distribution of pathogens in the lung infection group. Perform univariate analysis on the general data of two groups of patients and use multivariate logistic regression analysis to screen for independent risk factors affecting pulmonary infection in COPD patients. The results of univariate analysis showed that the ratio of patients aged ≥ 60 years, complicated with diabetes, duration of hospitalization ≥ 15 days, type of antimicrobial agents ≥ 2, and transforming growth factor-β (TGF-β) and serum tumor necrosis factor-α (TNF-α) in the pulmonary infection group were significantly greater than those in the group without pulmonary infection. Forced vital capacity (FVC) and forced expiratory volume in the first second (FEV1) were significantly lower than in the group without pulmonary infection ($P < 0.05$). Multivariate Logistic regression analysis showed that unrelated health risks for pulmonary infection in COPD patients were age ≥ 60 years, length of hospitalization ≥ 15 days, combination of diabetes mellitus, and use of ≥ 2 types of antibacterial drugs. Age ≥ 60 years old, hospital stay ≥ 15 days, diabetes patients, and antibacterial drugs ≥ 2 are the risk factors of COPD patients with pulmonary infection.

Keywords: chronic obstructive pulmonary disease (COPD); health risk; *klebsiella pneumoniae*; lung infection; pathogenic bacteria

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Introduction

Chronic obstructive pulmonary disease (COPD) is a global and incurable disease characterized by continuous airflow obstruction, including persistent emphysema or chronic bronchitis (Feldman et al. 2023a). Common symptoms of the disease include continual chronic cough and sputum production, breathless or frequent difficulty breathing, wheezing, chest tightness, and intermittent fatigue (Lahmar et al. 2022). The major cause of COPD is Smoking, which accounts for more than 90% of COPD patients in developed countries. Patients with COPD exhibit different symptoms at different stages of the disease. According to the classification methods and standards of the World Health Organization in 2018, the method of vital capacity is used to determine the stage of COPD, which is divided into four stages corresponding to different degrees of lung function (Janjua et al. 2021; Singh 2021; Lahmar et al. 2022). Other studies have shown that chronic respiratory diseases are the top three causes of global mortality, and COPD is the most important cause (Janjua et al. 2021; Singh 2021). Although the clinical attention on COPD has been increasing in recent years, research on its pathogenesis and treatment still needs to be further investigated.

After the onset of COPD, the airway is in a long-term inflammatory state for a long time, the lung structure is changed, the ability of the airway to resist external infection is reduced, and the patient is vulnerable to pathogen invasion and lung infection (D'Anna et al. 2021; Han et al. 2022). Lung infection can aggravate the inflammatory response, increase the burden on the lungs and heart, and aggravate the disease. Combined lung infection not only

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increases the cost of hospitalization but also affects the safety of the patient (Celli et al. 2021; Cross et al. 2022; Yang et al. 2023). Therefore, timely control of pulmonary infection is of great importance for alleviating acute aggravation symptoms, alleviating pulmonary function impairment, and improving prognosis in patients (Li et al. 2022; Yang et al. 2023). The characteristics of the diagnosis and treatment of various infectious bacteria in the respiratory tract of patients with lung infections are worthy of further study (Li et al. 2022). At present, there are some studies on the influencing aspects of lung infection in patients with COPD, but no consensus has been reached (Oba et al. 2018; Li et al. 2022; Yang et al. 2023). Based on this, this study aimed to probe the distribution characteristics of infective bacteria and related risk aspects of lung infection in patients with COPD and provide sources for the clinical prevention and treatment of lung infection.

Materials and Methods

General data

A retrospective analysis was conducted on the clinical data of 108 patients with chronic obstructive pulmonary disease complicated with pulmonary infection admitted to the First Affiliated Hospital of Anhui Medical University from October 2020 to May 2023, and they were included as the pulmonary infection group. The clinical information of 108 patients with COPD who did not develop lung infection during the same period were retrospectively examined, and they were considered as the group without pulmonary infection.

The diagnostic criteria of the Primary Diagnosis and Treatment Guidelines for COPD (Practice Edition 2018): (1) chronic cough, dyspnea, or intermittent sputum; (2) history of exposure to risk factors; and (3) pulmonary function test after inhalation of a bronchodilator, FEV1/forced vital capacity (FVC) < 0.70, with persistent airflow limitation. Patients in the pulmonary infection group also met the relevant diagnostic basis in Internal Medicine (7th Edition), and were diagnosed with pulmonary infection if they met any of the following three diagnostic criteria: (1) there were changes in new inflammatory infiltrating foci in the chest radiograph; (2) body temperature ≥ 37.5°C; (3) respiratory symptoms such as chest tightness and chest pain appear; (4) different degrees of lung consolidation signs and both lungs can be heard and dry, wet rales. Written informed consent was obtained from all patients. The study protocol was approved by the Ethics Committee of the First Affiliated Hospital of the Anhui Medical University (No. 220201001).

Inclusion criteria

The inclusion criteria were as follows: (1) patients who met the diagnostic criteria of COPD; (2) patients aged between 40 and 80 years; and (3) patients who gave informed consent.

Exclusion criteria

The exclusion criteria were as follows: (1) patients with allergy to the medication used in this study; (2) patients with severe heart, liver, or lung dysfunction; (3) patients with malignant tumors or systemic immune diseases; (4) patients with a recent history of surgery; and (5) patients taking medication that was different from the study medication.

Pathogen identification

Sputum coughed up by patients with pulmonary infection was taken as a sample, and microbial identification and drug sensitivity analysis (Hangzhou Bori Technology Co., LTD.) were used for detection. The species are gram-negative bacteria (including *Acinetobacter bauerii, Klebsiella pneumoniae, Pseudomonas aeruginosa, Enterobacter cloacae, Escherichia coli*), gram-positive bacteria (including *Staphylococcus aureus*, Enterococcus, and coagulase-negative Staphylococcus), and fungi (including *Candida albus, Candida tropicalis*).

Inflammatory factor detection

Approximately 3 ml of venous blood was obtained from all patients in the fasting state and placed in a centrifugal device (centrifugal parameters: 3000 rpm, 10 min). After further centrifugation, collect the serum. Then, ELISA kits were used to measure serum Tumor necrosis factor-α (TNF-α) and Transforming Growth Factor-β (TGF-β) levels according to the manufacturer's protocols. All operations are carried out under the guidance of the kit instructions.

Pulmonary function test

Forced vital capacity (FVC) and forced expiratory volume in the first second (FEV1) were calculated using a pulmonary function detector (Guangzhou Changhu Medical Equipment Co., Ltd.). FVC, FEV1 were performed by spirometry (SensorMedics Vmax 20C; Yorba Linda, CA, USA). Spirometry was conducted in triplicate while the patient was in a seated position. The highest FEV1, FVC values were recorded after examining all of the acceptable curves, even if they were not from the same curve. After management of COPD exacerbation, these measurements were repeated.

Observational index

(1) The distribution of infective strains in the sputum of patients in the lung infection group was analyzed. (2) Univariate analysis was performed on the clinical information of the two groups of patients, such as age, sex, whether they had diabetes complications, length of hospital stay (< 15 days, ≥ 15 days), whether they were mechanically ventilated, types of antibiotics used (< 2 kinds, ≥ 2 kinds), and whether they had indentured cathedrals. The serum TNF alpha, TGF-beta and FVC, FEV1 levels, etc. (3) Multivariate Logistic regression analysis was used to ana-

lyze variables with statistically significant differences in the results of univariate analysis, and to screen out independent risk aspects affecting lung infection in patients with COPD.

Statistical analysis

SPSS 22.0, a statistical software, was used to examine the information in this study. Statistical information is expressed as [example (%)], and the $\chi 2$ test was used. The S-W test was employed to confirm that the measurement information in this study was normally distributed, indicated as ($x \pm s$), and an independent t-test was employed for comparison between the two groups. Multivariate Logistic regression analysis was used to examine risk factors. Statistical significance was set at $P < 0.05$.

Results

Distribution of infective bacteria in lung infection group

In 108 sputum samples from patients in the lung infection group, 140 infective bacteria were identified, among which gram-negative bacteria accounted for the highest proportion (mainly *Klebsiella pneumoniae*), as shown in Table 1.

Table 1. Distribution of pathogenic bacteria in pulmonary infection group.

Pathogenic bacteria	Strain	Constituent ratio (%)
Gram-negative bacterium	87	62.14
Klebsiella pneumoniae	34	24.29
Acinetobacter baumannii	32	22.86
Pseudomonas aeruginosa	12	8.57
Escherichia coli	4	2.86
Enterobacter cloacae	4	2.86
others	1	0.71
Gram-positive bacterium	35	25.00
Staphylococcus aureus	12	8.57
enterococcus	9	6.43
coagulase-negative staphylococcus	8	5.71
others	6	4.29
Fungus	18	12.86
Candida albicans	10	7.14
Candida tropicalis	8	5.71
Total	140	100.00

Single factor analysis of pulmonary infection in patients with COPD

Examination of the clinical information of patients in the untreated group and the observation group showed that the proportion of patients aged ≥ 60 years, complicated with diabetes, duration of hospitalization ≥ 15 days, type of antibacterial drugs ≥ 2 types, and serum levels of TNF-α and TGF-β in the pulmonary infection group were remarkably greater than those in the group without pulmonary infection. The FVC and FEV1 values were significantly lower than those in the group without pulmonary infection (all $P < 0.05$), as shown in Table 2.

Multivariate logistic regression analysis of lung infection in patients with COPD

Indicators with statistically remarkable variations in the univariate analysis were considered independent variables, and whether lung infection occurred was considered a dependent variable, and the multivariate logistic regression analysis model was included. The results showed that the independent risk factors for lung infection in patients with COPD were age ≥ 60 years, length of hospitalization ≥ 15 days, combination of diabetes mellitus, and type of antibacterial drugs ≥ 2, with statistical significance (OR = 1.280, 5.726, 2.575, and 2.337, respectively; all $P < 0.05$), as shown in Table 3.

Through our research results, targeted measures can be developed to achieve our goal of improving patient prognosis.

Discussion

The airways of patients with COPD are in a state of chronic inflammation, the ability of the airways to clear cilia and other foreign bodies is reduced, mucosal edema and congestion, and excessive secretion of glands increase the risk of pulmonary infections (Oba et al. 2018; Suissa et al. 2022; Feldman et al. 2023b). When the patient is combined with lung infection, it can cause severe lung ventilation and air exchange disorders, and even lead to hypoxemia, resulting in respiratory failure and further deterioration of lung function (Leitao et al. 2021). In addition, drug-resistant bacterial infections can easily occur during treatment, which leads to increased difficulty in treatment and even death (Leitao et al. 2021; Fukuda et al. 2023). Therefore, a study to determine the etiological distribution and related influencing factors of pulmonary infection in patients with COPD is conducive to improving the quality of life of patients and reducing mortality. The results of this study showed that Gram-negative bacteria accounted for a higher number of pathogenic bacteria in the pulmonary infection group. This may be because gram-negative bacteria colonize the human respiratory mucosa more strongly, resulting in a higher risk of local respiratory infection (Pei et al. 2022; Fukuda et al. 2023). Therefore, in patients after admission, the need to collect the secretions, pathogen detection, resistance screening tests, and reasonable choice and use of antimicrobial agents to reduce the risk of lung infection (Pei et al. 2022). For common *Klebsiella pneumoniae*, due to its resistance to gentamicin and cephalosporin to varying degrees, carbapenem antibiotics can be selected for treatment, and the administration dose can be evaluated based on the condition of the patients to decrease the generation of drug resistance (Carrera-Salinas et al. 2023).

In this study, multivariate logistic regression analysis results showed that the separate risk factors for pulmonary

Table 2. Single factor analysis of pulmonary infection in patients with COPD.

Clinical data	Pulmonary infection group (n = 108)	Non-pulmonary infection group (n = 108)	$\chi 2$ /t value	P value
Age (n)			6.837	0.009
< 60	35	52		
≥ 60	73	56		
Gender (n)			0.101	0.764
Male	77	75		
Female	31	33		
Combined diabetes (n)			6.248	0.011
Yes	83	64		
No	25	44		
Hospital stays (n)			6.026	0.013
<15d	45	61		
≥ 15d	63	47		
Mechanical ventilation (n)			2.187	0.254
Yes	94	88		
No	14	20		
Types of antimicrobial drugs used (n)			7.265	0.005
< 2	25	43		
≥ 2	83	65		
Indwelling catheter (n)			1.694	0.358
Yes	49	52		
No	59	56		
TNF-α (x ± s, ng/L)	1.91 ± 0.31	1.23 ± 0.19	14.362	0.008
TGF-β (x ± s, ng/L)	97.8 ± 7.94	82.65 ± 7.42	9.648	0.018
FVC (x ± s, L)	2.02 ± 0.31	2.43 ± 0.45	7.081	0.023
FEV1 (x ± s, L)	1.38 ± 0.14	1.83 ± 0.26	14.076	0.009

Table 3. Multivariate Logistic regression analysis of pulmonary infection in patients with COPD.

Variate	β value	SE value	OR value (95% CI)	P value
Age (≥ 60)	0.246	0.116	1.279 (1.014-1.623)	0.025
Hospital stays (≥ 15d)	1.732	0.318	5.645 (3.124-10.987)	0.008
Combined diabetes	0.897	0.458	2.631 (1.024-6.125)	0.013
Types of antimicrobial drugs used (≥ 2)	0.798	0.425	2.487 (1.015-5.643)	0.037
TNF-α	0.385	0.227	1.362 (0.891-2.134)	0.124
TGF-β	0.362	0.248	1.328 (0.913-2.267)	0.134
FVC	0.748	0.619	2.187 (0.634-5.128)	0.087
FEV1	0.826	0.483	2.427 (0.873-4.625)	0.064

infection in patients with COPD were age ≥ 60 years, length of hospital stay ≥ 15 days, combined diabetes, and type of antibiotics ≥ 2. The reason may be that COPD has a slow onset and a long course of disease, and patients will have poor nutritional status under the long-term influence of the disease (Pei et al. 2022; Carrera-Salinas et al. 2023; Fukuda et al. 2023). With the increase in age, the patient's various physical and gastrointestinal functions decline, which aggravates malnutrition, resulting in weakening of the body's immune barrier, difficulty in resisting pathogens, and causing lung infection. In this regard, elderly patients can develop a reasonable diet plan according to their conditions and personal preferences, eat more foods rich in proteins and vitamins, ensure nutritional intake, and improve immunity (Wang 2021; Carrera-Salinas et al. 2023). For those with poor nutritional status, nutritional solutions and human blood albumin can be administered to enhance body resistance. In addition, patients should be urged to moderate exercise training to improve physical fitness, enhance resistance, and reduce the risk of lung infection (Miravitlles et al. 2021; Wang 2021).

The longer the patient stays in the hospital, the higher

the risk of iatrogenic infection, and the admission of other infected persons in the ward will also increase the chance of cross-infection. In addition, after the onset of the disease, immune system dysfunction of the body creates an environment beneficial to the infection by infective bacteria, thus increasing the risk of lung infection (Mkorombindo and Dransfield 2020; Miravitlles et al. 2021). Therefore, a reasonable treatment plan should be adopted to stabilize the patient's condition, improve the therapeutic effect, and shorten hospitalization time. Simultaneously, disinfection and isolation systems should be strictly implemented during hospitalization (Mathioudakis et al. 2020). Ozone or 2% peracetic acid spray should be used for disinfection in the ward every day, the floor should be wiped with chlorine-containing disinfectant every day, and relevant facilities should be disinfected regularly to reduce the risk of infection during hospitalization (Mathioudakis et al. 2020; Mkorombindo and Dransfield 2020).

Patients with diabetes mellitus have poor blood sugar control, and a high blood sugar level for a long time leads to increased plasma osmotic pressure, inhibits the phagocytic function of neutrophils and the monocytic system, and is more conducive to bacterial invasion and reproduction, providing the opportunity to cause lung infection (Di Pasquale, et al. 2020; Mathioudakis et al. 2020; Singh 2020). At the same time, patients with diabetes have fewer capillaries in the lungs, less active substances on the lung surface, and are more likely to develop lung infection (Singh 2020; Deng et al. 2021). In view of this, for patients with diabetes mellitus, multi-department joint consultation should be initiated, the blood sugar level of patients should be regularly detected, and patients should be treated with diet, drugs, and other methods to stabilize their blood sugar levels and reduce the adverse factors causing lung infection (Mintz et al. 2023). This study explores the distribution characteristics of infectious bacteria and related risk factors in COPD patients with pulmonary infections, providing a basis for clinical prevention and treatment of pulmonary infections.

Conclusion

The infective bacteria in patients with COPD complicated by lung infection were gram-negative bacteria, and *Klebsiella pneumoniae* accounted for a higher proportion. In addition, age ≥ 60 years, length of hospitalization ≥ 15 days, combination of diabetes mellitus, and type of antibacterial drugs ≥ 2 are risk factors for lung infection in patients with COPD, and patients can take corresponding measures to prevent lung dysfunction and improve their prognosis.

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Authors Contribution

Jinghan Jiang designed this study. Shaojun Huang drafted the original manuscript. Jinghan Jiang supervised the study. All authors have read and approved the final version of the manuscript.

Conflict of Interest

The authors declare no conflict of interest.

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