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EC PULMONOLOGY AND RESPIRATORY MEDICINE

Research Article

Observation on the Therapeutic Effect of Lianhua Qingke Tablets on Airway Mucus Hypersecretion in Patients with Acute Exacerbation of Chronic Obstructive Pulmonary Disease

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Received: August 13, 2025; **Published:** September 09, 2025

Abstract

Objective: To evaluate the efficacy of Lianhua Qingke Tablets (LHQKT) in reducing airway mucus hypersecretion and improving quality of life in patients with acute exacerbation of chronic obstructive pulmonary disease (AECOPD).

Methods: A total of 200 hospitalized AECOPD patients were enrolled and randomly assigned to either the control group or the treatment group. Baseline characteristics, clinical symptoms, pulmonary function, and blood indices were compared between the two groups.

Results: Baseline characteristics were balanced between the two groups except for a significant difference in gender distribution ($P < 0.05$). After treatment, the observation group exhibited a significantly greater reduction in COPD Assessment Test (CAT) scores and sputum volume scores compared to the control group. Additionally, forced expiratory volume in 1 second percent predicted (FEV1%pred) and partial pressure of oxygen (PO_2) were significantly improved, and the 6-minute walking distance (6MWD) increased in the observation group, whereas no significant changes were observed in the control group. Inflammatory marker analysis revealed that only C-reactive protein (CRP) levels were significantly reduced in the observation group ($P < 0.05$), with no statistically significant differences in other inflammatory markers. No differences were observed in safety indices between the two groups.

Conclusion: LHQKT effectively alleviated cough and sputum symptoms, improved pulmonary function and exercise tolerance, and enhanced quality of life in AECOPD patients, demonstrating a favorable safety profile.

Keywords: *Lianhua Qingke Tablets; Acute Exacerbation of Chronic Obstructive Pulmonary Disease (AECOPD); Airway Mucus Hypersecretion*

Introduction

Chronic Obstructive Pulmonary Disease (COPD) is a prevalent chronic respiratory disorder characterized by persistent airflow limitation [1]. According to statistics, over 300 million people worldwide are affected by COPD, and with worsening environmental pollution and population aging, the occurrence rate and mortality of COPD continue to rise annually, imposing a profound societal and economic burden [2]. Acute Exacerbation of COPD (AECOPD) is a critical event in the disease progression and represents a leading cause of death among COPD patients globally [3]. The mechanism of airway mucus hypersecretion is not only one of the most prominent clinical manifestations of COPD but also a profound pathophysiological alteration [4]. Airway mucus hypersecretion is closely associated with declining lung function, disease exacerbation, hospitalization, and mortality in COPD patients [5]. AECOPD is typically linked to aggravated airway inflammation, increased mucus secretion, and significant air trapping, all of which contribute to worsening dyspnea and further accelerate disease progression [3]. Therefore, targeting airway mucus hypersecretion and effectively promoting mucus clearance to alleviate airway obstruction are pivotal in the management of AECOPD.

Lianhua Qingke Tablet (LHQKT) is a compound traditional Chinese medicine preparation with demonstrated phlegm-resolving, antitussive, lung-diffusing, and heat-clearing effects. Its therapeutic efficacy in treating acute tracheitis and bronchitis has been confirmed both *in vitro* and *in vivo* [6,7], and it has been widely used in clinical practice. Despite these advancements, the specific therapeutic effects of LHQKT in AECOPD patients remain unclear. This study aims to evaluate, through a randomized controlled clinical trial, the efficacy of LHQKT in alleviating airway mucus hypersecretion, improving cough and expectoration, and enhancing quality of life in AECOPD patients, thereby providing new therapeutic strategies for traditional Chinese medicine in AECOPD management.

Subjects and Methods

Selection of study subjects

A total of 200 patients with acute exacerbation of AECOPD hospitalized at the First People's Hospital of Yinchuan from December 2022 to December 2024 were enrolled and randomly assigned to two groups (n = 100 per group). The control group received conventional treatment (anti-inflammatory therapy, oxygen therapy, and inhaled corticosteroid [ICS] plus long-acting β2-agonist [LABA]), while the observation group was administered Lianhua Qingke tablets (4 tablets, 3 times daily for 7 days) in addition to the conventional treatment.

Inclusion criteria:

1. All patients met the diagnostic criteria for chronic obstructive pulmonary disease (COPD) as defined by the Chinese Thoracic Society Guidelines for the Diagnosis and Treatment of COPD (2021 Revision) [8] and the 2021 Global Initiative for Chronic Obstructive Lung Disease (GOLD) guidelines [9].
2. Patients presented with a typical medical history, confirmed by physical examination and radiographic evidence (chest X-ray or computed tomography [CT]).
3. Pulmonary function test results showed a post-bronchodilator ratio of forced expiratory volume in 1 second to forced vital capacity (FEV1/FVC) <70%.
4. Patients exhibited acute exacerbation of symptoms, including increased cough, sputum production (purulent or mucopurulent), dyspnea, and/or wheezing, with or without fever, necessitating outpatient or inpatient treatment.

Exclusion criteria:

1. Patients with concurrent other respiratory diseases, including bronchial asthma, active pulmonary tuberculosis, lung cancer, primary bronchiectasis, pneumoconiosis, and other pulmonary restrictive ventilation dysfunction;
2. Patients receiving long-term use of other antitussive or expectorant medications;

3. Patients with severe cardiac, hepatic, or renal insufficiency;
4. Patients with comorbid severe psychiatric disorders or intellectual disabilities who are unable to cooperate with the examination.

Observation indicators and detection methods:

1. **General information:** Name, sex, age, height, body weight, educational level, medical history, past history, and personal history were collected via questionnaire.
2. **COPD assessment test (CAT) score:** The questionnaire consisted of the following items, with a total score of 40. Higher scores indicated more severe symptoms.

Example: I am very happy	0	1	2	3	4	5	I am very sad
I never cough	0	1	2	3	4	5	I cough all the time
I have no phlegm (mucus) in my chest at all	0	1	2	3	4	5	My chest is completely full of phlegm (mucus)
My chest does not feel tight at all	0	1	2	3	4	5	My chest feels very tight
When I walk up a hill or one flight of stairs I am not breathless	0	1	2	3	4	5	When I walk up a hill or one flight of stairs I am very breathless
I am not limited doing any activities at home	0	1	2	3	4	5	I am not limited doing any activities at home
I am confident leaving my home despite my lung condition	0	1	2	3	4	5	I am not at all confident leaving my home because of mu lung condition
I sleep soundly	0	1	2	3	4	5	I don't sleep soundly because of my lung condition
I have lots of energy	0	1	2	3	4	5	I have no energy at all

Table A

3. **Sputum volume scale score:** The questionnaire comprised the following items, with higher scores indicating greater sputum production.

Symptoms	Scoring
No coughing or expectoration	0
During the day, there are intermittent coughs, which are mild in severity. The amount of phlegm coughed out is 10 to 50 milliliters per day, both day and night.	2
Frequent coughing, but not affecting sleep. Coughing up 50-100ml of phlegm during both day and night.	4
Excessive coughing throughout the day and night, or intermittent coughing, which affects sleep, and expectoration of more than 100ml of phlegm during the day and night.	6

Table B

4. **Pulmonary function testing:** Pulmonary function parameters were determined using a spirometer from the Department of Pulmonary and Critical Care Medicine at Yinchuan First People's Hospital. Under the guidance of specialized physicians, the following parameters were measured and recorded for analysis: FEV1/FVC and percentage of predicted forced expiratory volume in one second (FEV1%).

5. **Arterial blood gas analysis:** Arterial blood gas measurements were performed using a blood gas analyzer from the Department of Pulmonary and Critical Care Medicine at Yinchuan First People's Hospital. The following parameters were collected for investigation: pH, partial pressure of carbon dioxide (PCO_2), and partial pressure of oxygen (PO_2).
6. **Six-minute walk test:** The six-minute walk test (6MWT) was administered to patients by specialized physicians following comprehensive pre-test evaluation of patient conditions. The total walking distance was recorded.
7. **Blood parameter analysis:** Complete blood counts including white blood cell count, lymphocyte count, neutrophil count, and eosinophil count were measured using an automated hematology analyzer in the Clinical Laboratory Department of Yinchuan First People's Hospital. C-reactive protein (CRP), alanine aminotransferase (ALT), gamma-glutamyl transferase (GGT), blood urea nitrogen (BUN), and serum creatinine (Scr) levels were determined using an automated biochemical immunoanalyzer. Interleukin-6(IL-6) levels were measured using an automated chemiluminescence immunoassay system.

Statistical methods

Statistical analysis was performed using SPSS 26.0 software. Categorical data were presented as counts and percentages (%) and compared between groups using the chi-square test. Continuous data were expressed as mean ± standard deviation (SD). For normally distributed data, intergroup comparisons were conducted using the independent t-test, while non-normally distributed data were analyzed using nonparametric tests. Intragroup comparisons were performed using the paired t-test for normally distributed data, and the nonparametric test for paired data was applied when the normality assumption was violated. A $P< 0.05$ was considered statistically significant.

Results

General information

A total of 200 cases were included. The age range was from 46 to 96 years old. Among them, 133 cases (66.5%) were male and 67 cases (33.5%) were female. 136 cases (68.0%) had underlying diseases, and 64 cases (32.0%) did not. There were 100 cases in each of the control group and the observation group. Comparing the two groups, only gender showed a statistically significant difference ($P < 0.05$), as shown in table 1.

Variable	Control group (n = 100)	Observation group (n = 100)	t/x^2	P
Age (∑x ± s, years)	71.98 ± 9.424	69.73 ± 7.966	-1.823	0.07
Gender (%)			5.050	0.025
Female	41 (41%)	26 (26%)		
Male	59 (59%)	74 (74%)		
BMI (∑x ± s)	23.214 ± 3.550	23.574 ± 4.083	0.665	0.507
Combine underlying diseases (%)			0.092	0.762
Yes	67 (67%)	69 (69%)		
No	33 (33%)	31 (31%)		
Smoking history (%)			1.720	0.580
Yes	48 (48%)	50 (50%)		
No	52 (52%)	50 (50%)		

Table 1: *Two groups of general data.*

P value, comparison between the treatment group and the control group. P < 0.05 indicates a significant difference.

Comparison of CAT scores between the two groups

The CAT scores of both groups decreased after treatment compared with baseline values. However, no statistically significant difference was observed in the control group before and after treatment, whereas the observation group exhibited a statistically significant reduction (P < 0.001). Moreover, the post-treatment CAT score in the observation group was significantly lower than that in the control group (P = 0.001), as detailed in table 2 and figure 1.

Indicator		Control group (n = 100)	Observation group (n = 100)	Z	P
CAT score	Before treatment	21.00 (19.00, 23.00)	21.00 (18.00, 23.00)	-0.627	0.531
	After treatment	17.50 (16.00, 19.750)	16.00 (14.00, 18.00)**	-3.433	0.001

Table 2: *Changes in CAT scores before and after treatment in the two groups.*

*Internal comparison within the group: Compared before and after treatment, *P < 0.05, **P < 0.001.*

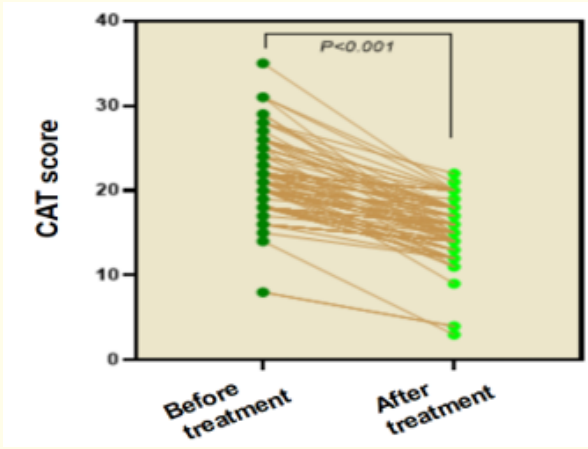

Figure 1: *Changes in CAT score before and after treatment in the observation group.*

Comparison of sputum volume scale scores between the two groups

Compared with baseline, no significant change in sputum volume scale scores was observed in the control group after treatment, whereas a significant reduction was noted in the observation group, with the difference being statistically significant (P < 0.001). See table 3 and figure 2 for details.

Indicator		Control group (n = 100)	Observation group (n = 100)	Z	P
Sputum volume scale score	Before treatment	4.00 (4.00, 6.00)	4.00 (4.00, 6.00)	-1.52	0.081
	After treatment	4.00 (2.00, 4.00)	2.00 (0.00, 2.00)**	1.71	0.087

Table 3: *Changes in sputum volume scale scores before and after treatment in both groups.*

*Internal comparison within the group: Compared before and after treatment, *P < 0.05, **P < 0.001.*

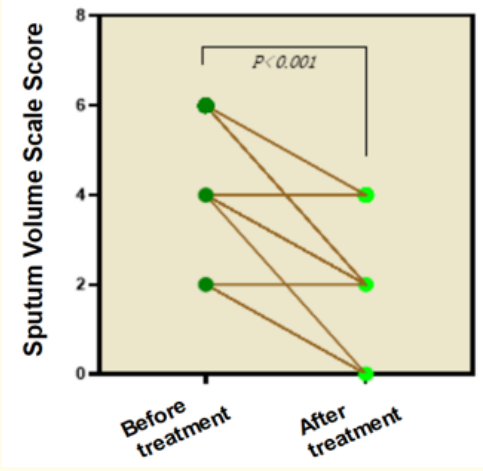

Figure 2: *Changes in the sputum volume scale score before and after treatment in the observation group.*

Comparison of blood gas parameters between the two groups

After treatment, the partial pressure of oxygen PO_2 increased in both groups compared with baseline. However, no statistically significant difference was observed in the control group before and after treatment, whereas a significant difference was found in the observation group (P < 0.001). No statistically significant differences were detected in pH or PCO_2 before and after treatment in either group. See table 4 and figure 3 for details.

Indicators		Control group (n = 100)	Observation group (n = 100)	Z/t	P
PH	Before treatment	7.376 (7.351, 7.413)	7.384 (7.357, 7.406)	-0.266	0.790
	After treatment	7.409 (7.380, 7.421)	7.391 (7.365, 7.417)	-1.808	0.071
PCO_2	Before treatment	38.750 (35.825, 42.825)	37.600 (34.900, 40.275)	-1.685	0.090
	After treatment	39.600 (34.800, 42.475)	36.900 (35.125, 41.150)	-1.618	0.106
PO_2	Before treatment	70.5500 (60.8250, 80.7000)	74.450 (60.625, 81.525)	-0.209	0.835
	After treatment	75.000 (65.400, 81.275)	78.400 (70.000, 84.450)**	-1.763	0.078

Table 4: *Changes in blood gas before and after treatment in both groups.*

*Internal comparison within the group: Compared before and after treatment, *P < 0.05, **P < 0.001.*

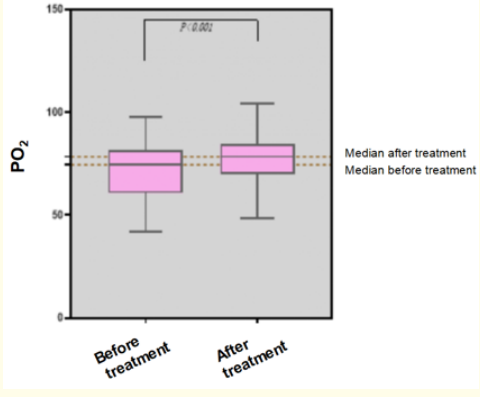

Figure 3: *Changes in PO_2 before and after treatment in the observation group.*

Comparison of pulmonary function between the two groups

Both groups exhibited improvements in FEV1/FVC and FEV1%pred after treatment compared to baseline. However, no statistically significant difference was observed in the control group before and after treatment, whereas a significant difference was noted in the observation group (P < 0.01). Moreover, post-treatment FEV1%pred in the observation group was significantly higher than that in the control group (P = 0.007). The detailed results are presented in table 5 and figure 4 and 5.

Indicators		Control group (n = 100)	Observation group (n = 100)	Z/t	P
FEV1/FVC (%)	Before treatment	60.275 (55.160, 65.640)	57.72 ± 9.19	-1.415	0.157
	After treatment	61.260 (56.742, 66.000)	60.29 ± 8.84**	-0.486	0.627
FEV1% pred	Before treatment	58.000 (46.275, 65.075)	56.750 (42.865, 62.300)	-1.743	0.081
	After treatment	60.890 (50.000, 66.750)	61.235 (43.625, 69.700)**	-2.704	0.007

Table 5: *Changes in pulmonary function before and after treatment in both groups.*

*Internal comparison within the group: Compared before and after treatment, *P < 0.05, **P < 0.001.*

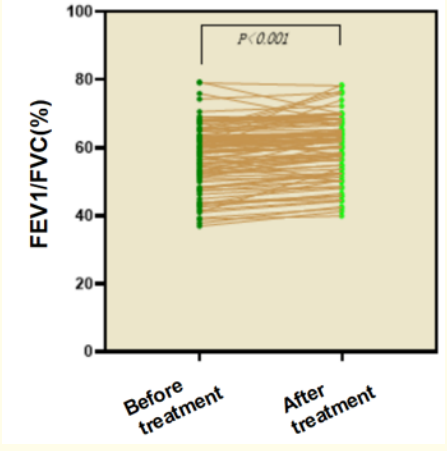

Figure 4: *Changes in FEV1/FVC before and after treatment in the observation group.*

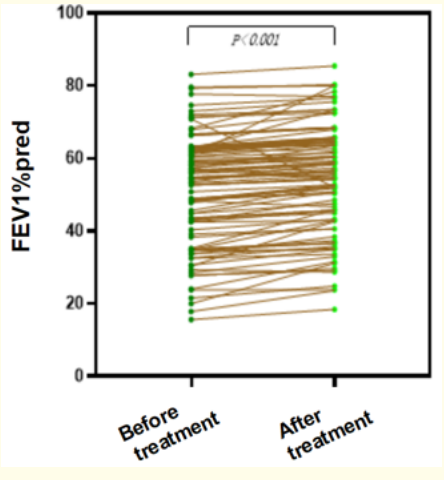

Figure 5: *Changes in FEV1 pred% before and after treatment in the observation group.*

Comparison of 6MWT between the two groups

The 6MWT distance increased in both groups after treatment compared to baseline. However, no statistically significant difference was observed in the control group before and after treatment, whereas a significant difference was noted in the observation group (P < 0.001). The detailed results are presented in table 6 and figure 6.

Indicator		Control group (n = 100)	Observation group (n = 100)	Z	P
6MWD (meter)	Before treatment	355.5 (331.0, 401.75)	358.0 (342.0, 400.0)	1.383	0.167
	After treatment	388.5 (368.0, 428.5)	395.0 (367.25, 425.07)**	0.115	0.909

Table 6: *Comparison of changes in 6MWD (meters) before and after treatment in both groups.*

*Internal comparison within the group: Compared before and after treatment, *P < 0.05, **P < 0.001.*

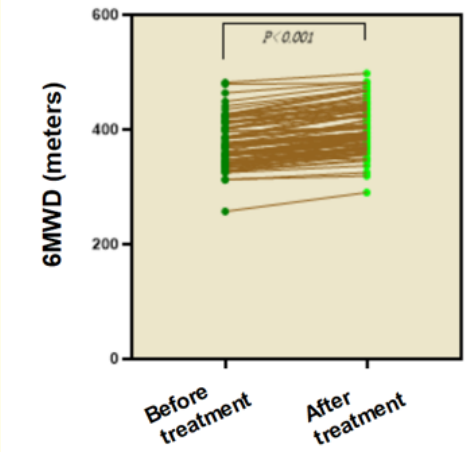

Figure 6: *Changes in 6MWD before and after treatment in the observation group.*

Comparison of inflammatory markers between the two groups

No statistically significant differences were observed in white blood cell count, lymphocyte count, neutrophil count, eosinophil count, or IL-6 levels between the two groups before and after treatment. However, a statistically significant difference was noted in CRP levels in the observation group before and after treatment (P < 0.05), as shown in table 7.

Indicators		Control group (n = 100)	Observation group (n = 100)	P
Blood cell count (10^9/L)	Before treatment	6.600 (5.400, 8.775)	7.627 ± 3.828	0.450
	After treatment	6.300 (5.200, 7.845)	6.150 (4.950, 7.550)	0.451
Lymphocyte count (10^9/L)	Before treatment	1.410 (0.962, 1.795)	1.456 ± 0.631	0.629
	After treatment	1.505 (1.040, 1.970)	1.435 (1.010, 1.912)	0.979
Neutrophil count (10^9/L)	Before treatment	4.580 (3.265, 6.385)	5.397 ± 3.670	0.759
	After treatment	4.060 (3.102, 5.517)	4.296 ± 1.731	0.733

Eosinophil count (10^9/L)	Before treatment	0.100 (0.040, 0.180)	0.188 ± 0.249	0.051
	After treatment	0.120 (0.052, 0.190)	0.125 (0.037, 0.140)	0.512
CRP (mg/L)	Before treatment	22.600 (4.650, 62.690)	23.190 ± 101.164	0.067
	After treatment	19.640 (2.455, 23.390)	16.707 ± 8.089*	0.074
IL-6 (pg/ml)	Before treatment	17.190 (7.900, 51.785)	46.630 ± 134.003	0.622
	After treatment	8.450 (3.115, 15.310)	15.7308 ± 14.325	0.870

Table 7: *Comparison of changes in inflammatory indicators before and after treatment in both groups.*

*Internal comparison within the group: Compared before and after treatment, *P < 0.05, **P < 0.001.*

Comparison of safety indicators between the two groups

No statistically significant differences were detected in ALT, GGT, BUN or Scr levels between the control and observation groups before and after treatment (P>0.05), as presented in table 8.

Indicators		Control group (n = 100)	Observation group (n = 100)	P
ALT (U/L)	Before treatment	14.600 (10.125, 22.500)	31.246 ± 118.860	0.405
	After treatment	17.200 (11.800, 25.600)	17.845 ± 9.362	0.873
GGT (U/L)	Before treatment	24.000 (16.050, 35.300)	32.668 ± 29.465	0.612
	After treatment	24.000 (17.600, 44.700)	37.350 (22.825, 67.825)	0.523
BUN (mmol/L)	Before treatment	5.470 (4.152, 6.600)	6.010 ± 3.669	0.970
	After treatment	5.105 (3.975, 6.287)	5.040 (3.810, 5.430)	0.455
Scr (umol/L)	Before treatment	68.150 (58.775, 78.925)	69.850 (62.225, 73.500)	0.553
	After treatment	66.200 (59.175, 76.000)	66.350 (61.425, 74.350)	0.466

Table 8: *Comparison of safety index changes before and after treatment in both groups.*

*Internal comparison within the group: Compared before and after treatment, *P < 0.05, **P < 0.001.*

Discussion

COPD is a prevalent and treatable respiratory disorder characterized by high morbidity, mortality, and disease burden [10]. AECOPD represents a critical event in the disease progression, leading to diminished quality of life, aggravated symptoms, accelerated lung function decline, increased mortality risk, prolonged hospitalization, and elevated socioeconomic burden [11]. AECOPD is predominantly associated with airway inflammation triggered by respiratory infections, wherein inflammatory cells (e.g. neutrophils, macrophages) release proinflammatory mediators, stimulating goblet cell hyperplasia and submucosal gland hypertrophy, ultimately resulting in excessive mucus secretion [12]. Airway mucus hypersecretion not only contributes to progressive lung function deterioration, severe activity limitation, and reduced quality of life in COPD patients but is also strongly correlated with a heightened risk of exacerbations, hospitalization, and mortality [4]. Consequently, reducing mucus accumulation and relieving airway obstruction are crucial for the management and prognosis of COPD. Early intervention and effective control of airway mucus hypersecretion hold profound clinical significance in alleviating symptoms, slowing lung function decline, improving quality of life, and reducing the frequency of exacerbations as well as hospitalization/mortality risk [10].

This randomized controlled study evaluated the therapeutic efficacy of LHQKT in AECOPD patients and its impact on quality of life. The results demonstrated that LHQKT significantly ameliorated airway mucus hypersecretion in AECOPD patients, as evidenced by a marked reduction in sputum production in the treatment group. These findings are consistent with the results obtained by Hao., *et al*. in a rat model of AECOPD [13]. Multiple active components in LHQKT exhibit notable antitussive and expectorant effects. For instance, hesperidin and hesperetin derived from Citri Reticulatae Pericarpium facilitate the clearance of airway mucus secretions and improve mucociliary function [14]. Active constituents in Fritillariae Thunbergii Bulbus and Glycyrrhizae Radix et Rhizoma enhance bronchial gland secretion, thereby reducing sputum viscosity [15-17]. Additionally, Fritillariae Thunbergii Bulbus promotes sputum expulsion by relaxing bronchial smooth muscles and enhancing ciliary movement [16].

Previous studies have demonstrated that various natural products, including baicalin, baicalein, and liquiritigenin, can reduce excessive airway mucus secretion and improve mucociliary clearance by suppressing the expression of mucin 5AC (MUC5AC) gene [18]. Research by Hao., *et al*. indicated that LHQKT inhibit goblet cell hyperplasia by modulating the expression of MUC5AC and aquaporin-5 (AQP5), thereby maintaining airway mucus homeostasis and ameliorating hypersecretion [13]. Experimental evidence suggests that LHQKT enhance mucociliary clearance capacity by preserving ciliary structural integrity and beating function [19]. Multiple active components in LHQKT exhibit significant antioxidant effects, scavenging free radicals and mitigating oxidative stress-induced lung tissue damage [7]. Compounds such as baicalin and forsythin in LHQKT suppress the nuclear factor-κB (NF-κB) signaling pathway, reducing the release of pro-inflammatory cytokines such as tumor necrosis factor-α (TNF-α) and IL-6, thereby alleviating airway inflammation [20]. Modern pharmacological studies reveal that LHQKT effectively ameliorate airway inflammation, reduce mucus secretion, and promote sputum expulsion through these multi-target mechanisms, achieving therapeutic efficacy in relieving cough and resolving phlegm.

This study demonstrated that LHQKT significantly improved pulmonary function in patients, as evidenced by enhanced pulmonary function parameters (including FEV1/FVC and FEV1% pred) and blood gas parameters (PO_2) in the observation group. LHQKT exerts its therapeutic effects on pulmonary ventilation through multi-component synergistic mechanisms: First, ephedrine, the primary active constituent of Ephedra, activates β2-adrenergic receptors to relax bronchial smooth muscle, thereby alleviating bronchospasm and asthma [21]. Second, Citri Reticulatae Pericarpium in the formulation modulates mucus secretion to reduce sputum viscosity, while Fritillaria enhances ciliary motility to facilitate sputum expectoration. The integrated pharmacological actions indicate that LHQKT achieves its antitussive and expectorant effects through a triple mechanism: (1) relieving bronchospasm and asthma, (2) diluting sputum, and (3) promoting sputum clearance. This synergistic approach alleviates airway obstruction in COPD patients, ultimately improving pulmonary function and increasing arterial oxygen partial pressure.

This study also demonstrated that LHQKT treatment significantly improved clinical symptoms and enhanced quality of life in patients, as evidenced by reduced CAT score and increased 6MWD post-treatment. The CAT scale comprehensively evaluates multiple dimensions including symptoms, activity limitation, psychological status, sleep quality, and social impact, thereby providing a holistic assessment of quality of life in COPD patients. The 6MWD serves as an integrated indicator of physical status, exercise capacity, and survival quality in COPD patients, representing a strong predictor of mortality. Notably, a 6MWD <350 meters is associated with increased mortality in this population [22]. Mechanistically, LHQKT alleviates airway obstruction, thereby improving pulmonary function. This therapeutic effect translates into ameliorated clinical symptoms, enhanced exercise tolerance, and ultimately, elevated quality of life.

Studies have demonstrated that *Forsythia suspensa*, *Scutellaria baicalensis*, Morus alba bark, and Mountain Honeysuckle in LHQKT can inhibit the release of inflammatory mediators, exhibiting anti-inflammatory effects [23]. However, this study found that, upon comparing the two patient groups before and after treatment, only CRP showed a statistically significant difference, while no significant differences were observed in white blood cell count, lymphocyte count, neutrophil count, eosinophil count, or IL-6. This discrepancy may be attributed to the fact that antibacterial agents were administered to both groups prior to treatment in this study. Additionally, the study revealed that

in AECOPD patients treated with Lianhua Qingke tablets, liver and kidney function indicators-including ALT, GGT, BUN, and Scr-showed no statistically significant differences compared to pre-treatment levels. These findings confirm the drug's favorable safety profile and indicate that it does not impose additional hepatic or renal burden.

Conclusion

In summary, this study demonstrates that Lianhua Qingke Tablet (LHQKT) exhibits significant efficacy in relieving cough and resolving sputum in patients with acute exacerbation of chronic obstructive pulmonary disease (AECOPD). The therapeutic advantages can be summarized into five key aspects: ① It dilutes sputum by modulating airway mucus secretion mechanisms while enhancing ciliary activity and motility to promote sputum expectoration. ② It reduces mucus hypersecretion by regulating MUC5AC gene expression, thereby decreasing airway mucus accumulation. ③ It alleviates bronchospasm by relaxing bronchial smooth muscle, facilitating sputum clearance. ④ It mitigates inflammatory damage to the airway mucosa by suppressing pro-inflammatory cytokines and mediators. ⑤ It demonstrates a favorable safety profile without imposing additional hepatic or renal burden. Therefore, LHQKT, with its multidimensional therapeutic benefits, represents a promising novel option for the clinical management of AECOPD.

Funding Support

This study was supported by the Luobing Syndrome Treatment-Guided Respiratory Disease Research Fund of the Chinese International Medical Foundation (Z-2014-08-2211), the Ningxia Hui Autonomous Region Science and Technology Innovation Leading Talent Program (2021GKLRLX03), the Yinchuan Science and Technology Plan Project (2024SFZD001), the Ningxia Hui Autonomous Region Key Research and Development Program (2018BEG03077), the Suzhou Collaborative Medical and Health Foundation Project (KY-079) and the Science and Technology Innovation Team of Yinchuan City (2023CXTD05). None of the funding agencies were involved in the study design, data collection, data analysis, data interpretation, or manuscript writing.

Authors' Contributions

LC conceived and designed the study, implemented the experimental protocol, performed data analysis and interpretation, and drafted the manuscript. ML contributed to manuscript writing. XK assisted in manuscript drafting and data collection. YY participated in data acquisition and statistical analysis. JC and HZ were responsible for study execution. XM led the conceptualization and design of the research protocol and provided academic supervision for manuscript content. All authors read and approved the final manuscript.

Acknowledgements

Thank you to all the participants who took part in this study.

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