Journal of Shahrekord University of Medical Sciences
doi: 10.34172/jsums.974 2025;27(4):146-151 http://j.skums.ac.ir

Original Article

Comparing the Effects of Oral Azithromycin with Standard Treatment in Patients with Chronic Obstructive Pulmonary Disease: A Double-Blind Randomized Controlled Trial

Ebrahim Abbasi Monjezi[1], Akbar Soleymani Babadi[2*], Alireza Kashefizadeh[3], Kiana Ronagh[4], Ali Ahmadi[5], Sharareh Raeisi[2]

[1]School of Medicine, Shahrekord University of Medical Sciences, Shahrekord, Iran
[2]Department of Internal Medicine, School of Medicine, Hajar Hospital, Shahrekord University of Medical Sciences, Shahrekord, Iran
[3]Shahid Dr. Labbafinejad Hospital, Shahid Beheshti University of Medical Sciences, Tehran, Iran
[4]School of Medicine, University of Queensland, Brisbane, Australia
[5]Department of Epidemiology, Modeling in Health Research Center, Shahrekord University of Medical Sciences, Shahrekord, Iran

*Corresponding Author: Akbar Soleymani Babadi, Email: a.soleimani@skums.ac.ir

Abstract

Background and aims: Data regarding the use of macrolide antibiotics in patients with chronic obstructive pulmonary disease (COPD) are limited and inconsistent. The objective of this study was to evaluate the effectiveness of adding azithromycin to the standard treatment regimen for patients with COPD.

Methods: In this clinical trial, 100 patients with COPD who were referred to the clinic and teaching hospitals of Shahrekord were divided into two groups. In addition to standard triple therapy (inhaled anticholinergic, inhaled bronchodilator, and inhaled corticosteroids), the experimental group received oral azithromycin at a dosage of 250 mg daily for two months. The control group received a placebo in conjunction with standard triple therapy. Both groups were assessed before and after the intervention using spirometry, blood oxygen saturation measurements, and the severity of dyspnea based on the Modified Medical Research Council (MMRC) criteria, as well as treatment outcomes. The data were analyzed using SPSS 22.0.

Results: Following the intervention, the mean forced expiratory volume in one second (FEV1) increased by 4.28 (95% confidence interval [CI]: 3.93 to 4.63) in the intervention group compared to an increase of 3.78 (95% CI: 3.43 to 4.13) in the control group ($P=0.004$). The mean oxygen saturation improved by 4.88% (95% CI: 4.53 to 5.23) in the intervention group as opposed to an increase of 4.28% (95% CI: 3.93 to 4.63) in the control group ($P=0.006$). However, the MMRC score decreased by -0.82 (95% CI: -0.92 to -0.72) in the intervention group compared to a decrease of -0.54 (95% CI: -0.64 to -0.44) in the control group ($P=0.002$).

Conclusion: The administration of azithromycin in conjunction with standard treatment demonstrated significantly improved outcomes compared to standard treatment alone.

Keywords: Azithromycin, Chronic obstructive pulmonary disease, FEV1, Spirometry, Pulmonary disease

Received: April 29, 2024, **Revised:** November 27, 2024, **Accepted:** November 30, 2024, **ePublished:** December 29, 2025

Introduction

Chronic obstructive pulmonary disease (COPD) is a progressive obstructive lung disease characterized by long-term respiratory issues, including shortness of breath, coughing, increased mucus production, and impaired airflow, which can result in wheezing (1, 2). The progressive nature of COPD complicates daily activities, such as dressing and walking. The increasing rates of smoking and industrialization in recent decades, along with the rising average age of the population, have contributed to a rise in the incidence of COPD, which now affects approximately 320 million people worldwide, representing 4.8% of the global population (3, 4). This increased incidence has led to COPD becoming the fourth leading cause of death worldwide, in addition to imposing significant economic burdens, both direct (medical expenses) and indirect (costs associated with absenteeism from work) (4, 5). Current treatment for COPD includes bronchodilators, inhaled corticosteroids, and anticholinergics, which are primarily used to manage symptoms (6). For hypoxemic patients, oxygen therapy and smoking cessation are additional interventions that can modify the natural progression of COPD and enhance survival (7). However, there is a need for supplementary therapies and treatment protocols to expedite the treatment process for patients and reduce the economic burden associated with COPD (7-9). One potential additional therapy is the use of macrolides, a

class of antibiotics characterized by a large macrocyclic lactone ring. Macrolides have been shown to contribute to clinical improvements in patients with severe and chronic pulmonary inflammatory diseases associated with recurrent bacterial colonization and chronic inflammation, such as diffuse bronchiolitis, asthma, and bronchiectasis related to cystic fibrosis and non-cystic fibrosis bronchiectasis (10, 11). However, there is limited and inconsistent information regarding the effectiveness of incorporating macrolide antibiotics into standard COPD treatment. Therefore, this study aims to evaluate the effectiveness of adding azithromycin, a macrolide, to the standard treatment regimen for COPD patients at Hajar Hospital in Shahrekord, Iran.

Materials and Methods

Study Design and Patients

This double-blind randomized controlled trial included patients diagnosed with COPD who were referred to clinics and teaching hospitals affiliated with Shahrekord University of Medical Sciences from January 2022 to December 2022. Patients underwent a clinical examination, during which data regarding their signs and symptoms were recorded on a data collection form. Additionally, patients underwent spirometry, which was conducted by a hospital-trained technician using a spirogram. COPD was classified based on a forced expiratory volume in one second (FEV1) of less than 80% and the patients' smoking history.

Inclusion and Exclusion Criteria

Regarding the inclusion criteria for this study, participants had to be willing to participate in the research, be in the age range of 40–70 years old, have a diagnosis of COPD established by an internal medicine physician, and have a history of hospitalization according to the Global Initiative for Chronic Obstructive Lung Disease classification system. Additionally, participants were required to demonstrate both mental and physical stability. On the other hand, the exclusion criteria included patients with immunodeficiency, pneumonia, asthma, allergic rhinitis, cancer, pulmonary embolism, renal failure, liver disease, hearing loss, exacerbated COPD, or an allergy to azithromycin.

Sample Size and Allocation

The convenience sampling method was employed in this study. Based on the findings of similar research (12) and limitations regarding the number of available patients, the sample size was determined to be 50 subjects in each group, resulting in a total sample size of 100 participants. The CONSORT diagram for the study is illustrated in Figure 1.

Interventions

The control group received standard triple therapy, which included inhaled anticholinergics (both long-acting and short-acting), inhaled bronchodilators (both long-acting and short-acting), and inhaled corticosteroids for two weeks, along with a placebo. Importantly, no patients were excluded from conventional treatments. The intervention group was administered oral azithromycin 250 mg (Tehran Shimi Company) daily for two months, in addition to the standard triple therapy. To ensure compliance with the intervention and monitor for potential side effects, the medication was provided to the patients for two weeks, with adherence monitored by the administrator via telephone every two weeks. Patients were also required to return the empty drug shells to the pharmacy technician for verification of compliance. Following the two-month trial period, all patients underwent a comprehensive clinical examination, during which their signs, symptoms, and spirometry results were recorded in the data collection form.

Primary Outcomes

The primary outcome of this study was the change in FEV1 from baseline to the end of the two-month intervention period. This measure was utilized to evaluate the effectiveness of the treatment in improving lung function.

Secondary Outcomes

Change in Chronic Obstructive Pulmonary Disease Symptoms

This was assessed through patient-reported symptoms, including breathlessness and cough severity, which were recorded using a standardized questionnaire.

Quality of Life

The COPD assessment test was employed to measure the impact of the treatment on patients' overall quality of life.

Frequency of Chronic Obstructive Pulmonary Disease Exacerbations

This was documented as the number of acute exacerbations requiring medical intervention during the study period.

Medication Adherence

Adherence to the prescribed treatment regimen was monitored through pill counts and patient self-reports.

Randomization

In this study, a block randomization method was utilized to assign individuals to groups, ensuring an equal number of patients in each group (50 patients per group) and maintaining balance between the groups. The randomization list was generated using Excel software, and each patient was assigned a unique identification number upon entry. Subsequently, the patients were allocated to either the intervention (case) group or the control group according to the randomization list.

Blinding Procedures

In this study, double-blind procedures were implemented

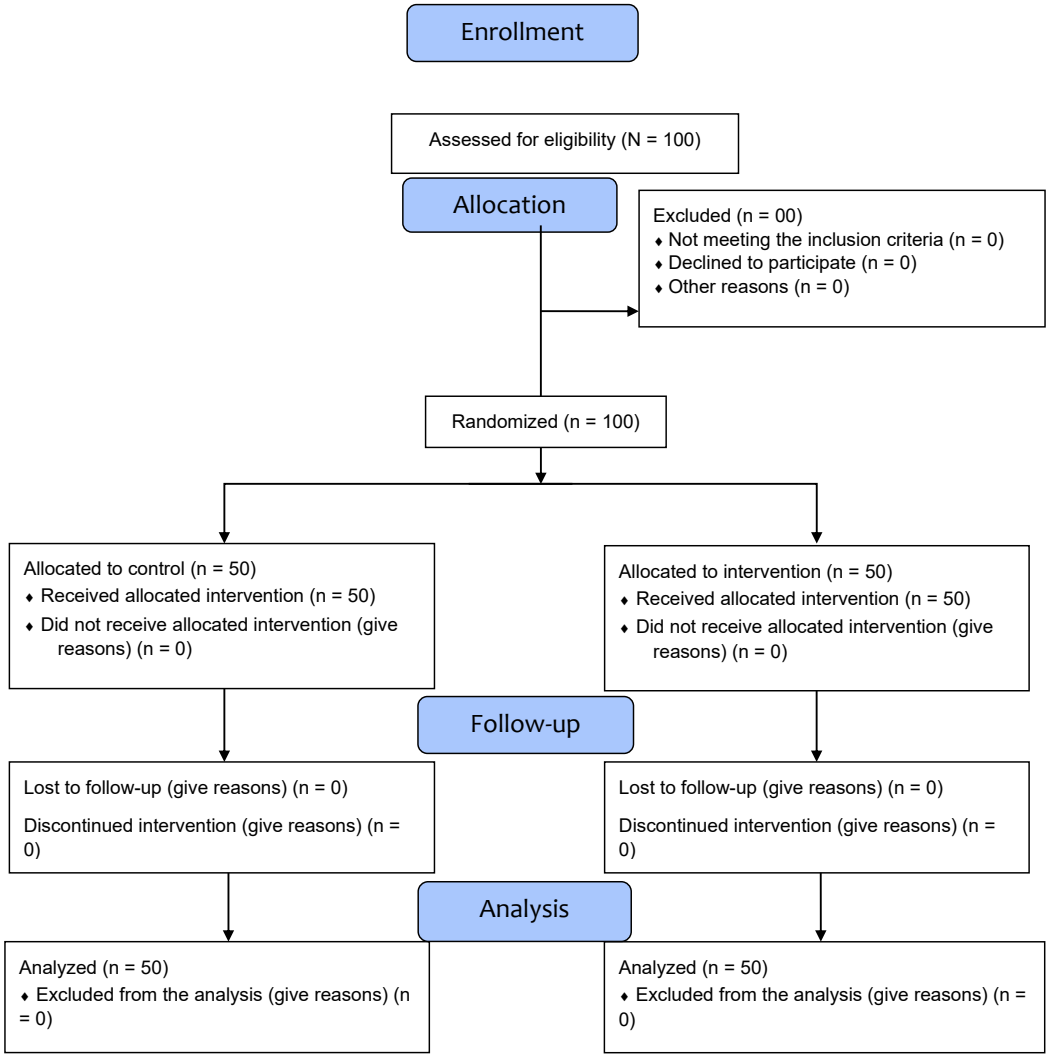

Figure 1. CONSORT Diagram for the participant screening

for both participants and investigators. The control group received a placebo instead of the azithromycin treatment. Medication packaging was coded, and an independent nurse was responsible for managing the allocation of the medications.

Statistical Analysis

The data were analyzed using SPSS software (version 22; IBM Corp., Armonk, NY, USA). Descriptive statistics, including frequencies and percentages for categorical data, as well as means and standard deviations for continuous variables, were calculated to summarize the data. The chi-squared test was employed to assess associations between categorical variables (e.g., the frequency of COPD exacerbations across the intervention groups). Independent t-tests were utilized to compare the mean changes in continuous outcomes (e.g., FEV1 and the quality of life scores) between the intervention and control groups. Statistical significance was defined as $P<0.05$. This comprehensive statistical approach was selected to ensure accurate and meaningful interpretation of the study's results.

Results

A total of 100 patients with COPD were recruited for the study. A comparison of the baseline quantitative characteristics of participants, including age, FEV1, FEV1/FVC ratio, oxygen saturation, and the Modified Medical Research Council (MMRC) scores, between the control and intervention groups indicated that there were no significant differences ($P>0.05$, Table 1).

Both the control and intervention groups demonstrated a statistically significant increase in FEV1 and oxygen saturation ($P<0.001$), as well as a statistically significant decrease in the mean MMRC score ($P<0.001$), following the intervention (Table 2).

The changes in FEV1, oxygen saturation, and MMRC scores before and after the intervention were significantly different between the control and intervention groups. The intervention group exhibited a statistically greater increase in FEV1 and oxygen saturation compared to the control group. Similarly, the change in MMRC scores in the intervention group was significantly greater than that in the control group ($P=0.002$, Table 3).

The outcomes were not statistically significant between

Table 1. Comparison of Baseline Characteristics of Patients in the Control and Intervention Groups

Variable	Control Group (Mean ± SD)	Intervention Group (Mean ± SD)	*P* value
Age (year)	63.42 ± 5.49	63.56 ± 4.83	0.829
FEV1	60.20 ± 7.47	59.5 ± 7.43	0.639
FEV1/FVC	66.78 ± 3.08	66.62 ± 2.42	0.773
Oxygen saturation (%)	80.28 ± 3.11	80.08 ± 2.82	0.737
MMRC	3.22 ± 0.50	3.16 ± 0.54	0.571

Note. SD: Standard deviation; FEV1: Forced expiratory volume in 1 second; FVC: Forced vital capacity; MMRC: Modified Medical Research Council.

Table 2. Comparison of Respiratory Function Tests: FEV1, Oxygen Saturation, and MMRC Scores Before and After Treatment in Both Control and Intervention Groups

Study Group	Variables	Before Intervention (Mean ± SD)	After Intervention (Mean ± SD)	*P* value
Control group	FEV1	60.20 ± 7.47	63.98 ± 7.73	<0.001
	Oxygen saturation	80.28 ± 3.11	84.56 ± 3.01	<0.001
	MMRC	3.22 ± 0.50	2.68 ± 0.62	<0.001
Intervention group	FEV1	59.50 ± 7.43	63.78 ± 7.41	<0.001
	Oxygen saturation	80.08 ± 2.82	84.96 ± 2.31	<0.001
	MMRC	3.16 ± 0.54	2.34 ± 0.68	<0.001

Note. SD: Standard deviation; FEV1: Forced expiratory volume in one second; MMRC: The Modified Medical Research Council.

Table 3. Comparison of Mean Changes in FEV1, Oxygen Saturation, and MMRC Scores Before and After Treatment in the Intervention and Control Groups

Variable	Control Group (Mean ± SD)	Intervention Group (Mean ± SD)	*P* value
Changes in FEV1	3.78 ± 0.86	4.28 ± 0.85	0.004
Changes in oxygen saturation	4.28 ± 0.15	4.88 ± 1.20	0.006
Changes in MMRC	-0.54 ± 0.50	-0.82 ± 0.38	0.002

Note. SD: Standard deviation; FEV1: Forced expiratory volume in one second; MMRC: The Modified Medical Research Council. The data are presented as means ± SDs for FEV1, oxygen saturation, and MMRC scores.

Table 4. Comparison of Outcomes in the Intervention and Control Groups

Variable		Control Group n (%)	Intervention Group n (%)	*P* value
Outcomes	Outpatient	41 (82)	46 (92)	0.288
	Hospitalization	3 (6)	2 (4)	
	Death	6 (12)	2 (4)	

the control and intervention groups ($P = 0.288$), although a greater percentage of patients in the control group were hospitalized or deceased compared to the intervention group (Table 4).

The data are presented as numbers (percentages) for outcome variables, including death, hospitalization, and outpatient visits. In the present study, patients were evaluated for side effects during the 2-month intervention period, and at the end of the two months, but none reported any side effects.

Discussion

This study evaluated the effectiveness of adding azithromycin to standard COPD therapy by comparing 100 patients divided into two groups: one receiving standard triple therapy with a placebo and the other receiving azithromycin in addition to standard therapy. Over two months, both groups showed significant improvements in FEV1, oxygen saturation, and dyspnea, with the intervention group demonstrating greater improvements. However, the difference between the groups was not statistically significant. Several studies to date have examined the efficacy of azithromycin in improving COPD outcomes and preventing exacerbations (13-15).

Bertens et al reported that long-term azithromycin treatment significantly reduces COPD exacerbation rates and improves patient outcomes (16). Similarly, Baalbaki et al found that azithromycin substantially lowered exacerbation rates and improved respiratory symptoms in COPD patients compared to controls (17). Additionally, Cui et al confirmed the beneficial effects of long-term azithromycin use in reducing exacerbations and enhancing the quality of life in COPD patients (18).

Likewise, the present study demonstrated a non-statistically significant reduction in the risk of hospitalization and mortality among azithromycin users. The lack of statistical significance is likely attributable to the small sample size of the study. Therefore, future research utilizing larger sample sizes and extended follow-up periods for patients is necessary. For instance, Baalbaki et al examined the effects of azithromycin in patients with COPD over one year and observed a non-significant reduction in hospitalization rates and mortality. This study underscored the need for larger-scale trials to confirm the efficacy of azithromycin in reducing these outcomes (17).

Moreover, Naderi et al concluded that the long-term use of azithromycin (250 mg, three times a week for six months) was associated with a reduction in the number of exacerbations among patients with severe COPD. Furthermore, the study indicated that the benefits of azithromycin persisted for over a year after the discontinuation of the medication (19).

Studies suggest that the clinical effects of macrolide antibiotics, including azithromycin, may be attributed to their ability to significantly reduce cytokine and chemokine production in COPD patients (20). Long-term, low-dose azithromycin treatment has also been associated with decreased expression of antigen-presenting genes, interferons, T cell responses, and various inflammatory pathways in the airways and bloodstream. Further, azithromycin has been shown to reduce exacerbations, sputum neutrophils, and bacteremia in patients with stable COPD and neutrophilic bronchitis (21, 22).

Many studies on the effectiveness of macrolide

antibiotics for COPD have focused on their impact on exacerbations rather than on spirometry parameters. Spirometry has been more commonly studied in other conditions, such as asthma. Nonetheless, evidence suggests that macrolides, with their broad-spectrum activity and favorable safety profile, play a crucial role in the management of COPD (23, 24).

The data indicate that macrolides offer a therapeutic advantage in patients with stable COPD due to their anti-inflammatory properties rather than their antibacterial activity. Consequently, macrolide antibiotics may be particularly important in managing chronic inflammatory airway disorders because of their pronounced anti-inflammatory effects. However, prolonged treatment of COPD patients with macrolides may lead to potential complications. In one study, some COPD patients treated with azithromycin for a year developed bacterial resistance and hearing loss (25).

Overall, before recommending macrolide antibiotics for COPD patients, it is essential to conduct larger, well-designed, longitudinal, and placebo-controlled studies. These studies should monitor both clinical parameters, such as treatment outcomes, laboratory findings, and spirometry, as well as side effects, including microbial resistance and infections with macrolide-insensitive bacteria.

Conclusion

Our findings demonstrated that the group receiving azithromycin in addition to standard treatment exhibited significantly better outcomes compared to the group receiving standard treatment alone, supporting the recommendation of azithromycin as an effective adjunct therapy for COPD patients. The findings further indicated that azithromycin is effective in improving spirometry, oxygen saturation, and dyspnea in COPD patients. However, azithromycin treatment did not result in statistically significant improvements in key outcomes of COPD, such as mortality, hospitalization, or outpatient visits; this lack of significance is likely attributable to the small sample size and the short follow-up period.

Acknowledgments

The authors wish to express their gratitude to the Vice-Chancellor for Research and Technology at Shahrekord University of Medical Sciences.

Authors' Contribution

Conceptualization: Ebrahim Abbasi Monjezi, Akbar Soleymani Babadi.
Data curation: Alireza Kashefizadeh, Sharareh Raeisi.
Formal analysis: Ebrahim Abbasi Monjezi.
Funding acquisition: Ebrahim Abbasi Monjezi, Kiana Ronagh.
Investigation: Ebrahim Abbasi Monjezi, Kiana Ronagh.
Methodology: Ebrahim Abbasi Monjezi, Akbar Soleymani Babadi.
Project administration: Akbar Soleymani Babadi.
Resources: Ali Ahmadi and Sharareh Raeisi.
Software: Ali Ahmadi.
Supervision: Akbar Soleymani Babadi.
Validation: Alireza Kashefizadeh, Ali Ahmadi, Sharareh Raeisi.
Visualization: Alireza Kashefizadeh, Sharareh Raeisi.
Writing–original draft: Ebrahim Abbasi Monjezi, Akbar Soleymani Babadi.
Writing–review & editing: Ebrahim Abbasi Monjezi, Akbar Soleymani Babadi.

Competing Interests

The authors declare that there is no conflict of interests.

Ethical Approval

The research was conducted in accordance with the principles of the Declaration of Helsinki. The Ethics Committee of Shahrekord University of Medical Sciences approved this study. The Institutional Ethical Committee at Shahrekord University of Medical Sciences accepted all study protocols (IR.SKUMS.REC.1399.109). Written informed consent was obtained from all participants prior to any intervention. Additionally, the trial protocol was registered and approved in the Iranian Registry of Clinical Trials (IRCT20210405050849N1).

Funding

This work was supported by the Research Deputy of Shahrekord University of Medical Sciences (Grant No. 5274).

References

1. Furtado RH, Berwanger O, Fonseca HA, Corrêa TD, Ferraz LR, Lapa MG, et al. Azithromycin in addition to standard of care versus standard of care alone in the treatment of patients admitted to the hospital with severe COVID-19 in Brazil (COALITION II): a randomised clinical trial. Lancet. 2020;396(10256):959-67. doi: 10.1016/s0140-6736(20)31862-6.
2. RECOVERY Collaborative Group. Azithromycin in patients admitted to hospital with COVID-19 (RECOVERY): a randomised, controlled, open-label, platform trial. Lancet. 2021;397(10274):605-12. doi: 10.1016/s0140-6736(21)00149-5.
3. Adhikari TB, Acharya P, Högman M, Neupane D, Karki A, Drews A, et al. Prevalence of chronic obstructive pulmonary disease and its associated factors in Nepal: findings from a community-based household survey. Int J Chron Obstruct Pulmon Dis. 2020;15:2319-31. doi: 10.2147/copd.S268110.
4. Montón C, Prina E, Pomares X, Cugat JR, Casabella A, Oliva JC, et al. Nebulized colistin and continuous cyclic azithromycin in severe COPD patients with chronic bronchial infection due to *Pseudomonas aeruginosa*: a retrospective cohort study. Int J Chron Obstruct Pulmon Dis. 2019;14:2365-73. doi: 10.2147/copd.S209513.
5. Alispahic IA, Eklöf J, Sivapalan P, Jordan AR, Harboe ZB, Biering-Sørensen T, et al. Risk of mortality and cardiovascular events in patients with chronic obstructive pulmonary disease treated with azithromycin, roxithromycin, clarithromycin, and amoxicillin. J Clin Med. 2024;13(7):1987. doi: 10.3390/jcm13071987.
6. Gyselinck I, Janssens W. Macrolide use in chronic obstructive pulmonary disease. In: Rubin BK, Shinkai M, eds. Macrolides as Immunomodulatory Agents. Cham: Springer International Publishing; 2024. p. 115-48. doi: 10.1007/978-3-031-42859-3_6.
7. Yao GY, Ma YL, Zhang MQ, Gao ZC. Macrolide therapy decreases chronic obstructive pulmonary disease exacerbation: a meta-analysis. Respiration. 2013;86(3):254-60. doi: 10.1159/000350828.
8. Parnham MJ, Norris V, Kricker JA, Gudjonsson T, Page CP. Prospects for macrolide therapy of asthma and COPD. Adv Pharmacol. 2023;98:83-110. doi: 10.1016/bs.apha.2023.03.002.
9. Nyström H, Ekström M, Berkius J, Ström A, Walther S,

Inghammar M. Prognosis after intensive care for COPD exacerbation in relation to long-term oxygen therapy: a nationwide cohort study. COPD. 2023;20(1):64-70. doi: 10.1080/15412555.2022.2106840.
10. Lam J, Tonnu-Mihara I, Kenyon NJ, Kuhn BT. Comparative effectiveness of roflumilast and azithromycin for the treatment of chronic obstructive pulmonary disease. Chronic Obstr Pulm Dis. 2021;8(4):450-63. doi: 10.15326/jcopdf.2021.0224.
11. Pomares X, Montón C, Bullich M, Cuevas O, Oliva JC, Gallego M, et al. Clinical and safety outcomes of long-term azithromycin therapy in severe COPD beyond the first year of treatment. Chest. 2018;153(5):1125-33. doi: 10.1016/j.chest.2018.01.044.
12. Wang X, Ji X. Sample size estimation in clinical research: from randomized controlled trials to observational studies. Chest. 2020;158(1S):S12-20. doi: 10.1016/j.chest.2020.03.010.
13. Herath SC, Normansell R, Maisey S, Poole P. Prophylactic antibiotic therapy for chronic obstructive pulmonary disease (COPD). Cochrane Database Syst Rev. 2018;10(10):CD009764. doi: 10.1002/14651858.CD009764.pub3.
14. Cazzola M, Rabe KF, Calzetta L, Hanania NA. Impact of azithromycin on the prevention of COPD exacerbations: a meta-analysis. Pulm Pharmacol Ther. 2020;64:101974.
15. Nakamura K, Fujita Y, Chen H, Somekawa K, Kashizaki F, Koizumi H, et al. The effectiveness and safety of long-term macrolide therapy for COPD in stable status: a systematic review and meta-analysis. Diseases. 2023;11(4):152. doi: 10.3390/diseases11040152.
16. Bertens LC, van der Valk PDLPM, Bonten TN, Dekhuijzen PNR, van der Meer V, Pieterse ME, et al. Long-term azithromycin in chronic obstructive pulmonary disease: a systematic review and meta-analysis. Respir Med. 2018;137:10-7. doi:10.1016/j.rmed.2018.02.007.
17. Baalbaki N, Giuliano C, Hartner CL, Kale-Pradhan P, Johnson L. Azithromycin versus beta-lactams in hospitalized patients with acute exacerbations of COPD. J Gen Intern Med. 2022;37(16):4183-8. doi: 10.1007/s11606-022-07486-5.
18. Cui Y, Luo L, Li C, Chen P, Chen Y. Long-term macrolide treatment for the prevention of acute exacerbations in COPD: a systematic review and meta-analysis. Int J Chron Obstruct Pulmon Dis. 2018;13:3813-29. doi: 10.2147/copd.S181246.
19. Naderi N, Assayag D, Mostafavi-Pour-Manshadi SM, Kaddaha Z, Joubert A, Ouellet I, et al. Long-term azithromycin therapy to reduce acute exacerbations in patients with severe chronic obstructive pulmonary disease. Respir Med. 2018;138:129-36. doi: 10.1016/j.rmed.2018.03.035.
20. Nichols DP, Odem-Davis K, Cogen JD, Goss CH, Ren CL, Skalland M, et al. Pulmonary outcomes associated with long-term azithromycin therapy in cystic fibrosis. Am J Respir Crit Care Med. 2020;201(4):430-7. doi: 10.1164/rccm.201906-1206OC.
21. Baines KJ, Wright TK, Gibson PG, Powell H, Hansbro PM, Simpson JL. Azithromycin treatment modifies airway and blood gene expression networks in neutrophilic COPD. ERJ Open Res. 2018;4(4):00031-2018. doi: 10.1183/23120541.00031-2018.
22. Heidary M, Ebrahimi Samangani A, Kargari A, Kiani Nejad A, Yashmi I, Motahar M, et al. Mechanism of action, resistance, synergism, and clinical implications of azithromycin. J Clin Lab Anal. 2022;36(6):e24427. doi: 10.1002/jcla.24427.
23. Sun XJ, He ZY. Macrolides for treatment of chronic obstructive pulmonary disease. Chin Med J. 2019;132(11):1261-3. doi: 10.1097/cm9.0000000000000248.
24. Morasert T, Kriengwattanakul O, Kulalert P. Effect of macrolide antibiotics on in-hospital mortality among acute exacerbation of COPD patients: a propensity score-matched analysis. Int J Chron Obstruct Pulmon Dis. 2022;17:2229-39. doi: 10.2147/copd.S373595.
25. Djamin RS, Talman S, Schrauwen EJ, von Wintersdorff CJ, Wolffs PF, Savelkoul PH, et al. Prevalence and abundance of selected genes conferring macrolide resistance genes in COPD patients during maintenance treatment with azithromycin. Antimicrob Resist Infect Control. 2020;9(1):116. doi: 10.1186/s13756-020-00783-w.