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RESEARCH ARTICLE

Heart Rhythm Disorders In Chronic Obstructive Pulmonary Disease: Frequency, Prognosis, And Therapy

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Abstract: ***Background***: The aim was to quantify the arrhythmia incidence in COPD, to analyse their prognostic value at 1-year horizon and compare the association with therapeutic strategies. The study is implemented as a reproducible simulation group of 480 respondents with distribution by GOLD I–IV stages and realistic risk profiles including age, hypoxemia and comorbidity. The modeling was based on the probabilistic relationships between hypoxemia, heart failure, the degree of obstruction, and the probabilities of atrial fibrillation, supraventricular tachyarrhythmias, frequent ventricular extrasystoles, and non-sustained ventricular tachycardia. The incidence of any arrhythmia was 74.6%, with a gradient of severity of obstruction increasing to 87.5% at stage IV. The difference in survival on the Kaplan–Mayer curves in the presence of arrhythmia compared with the absence was revealed, which is consistent with an increase in annual mortality from 13.1% to 22.1%. The average number of hospitalizations increased from 0.89 to 1.46 per patient in 1 year. The association of beta-blocker treatment indicated a protective trend for mortality, whereas inhaled steroids and long-term oxygen therapy showed a neutral relationship after taking into account the severity of the disease. The results highlight the clinical significance of rhythm monitoring and frequency control optimization in COPD, making the integration of cardiological and pulmonological approaches a viable option. The data and code are available for independent verification and re-analysis.

Keywords: COPD, arrhythmias, atrial fibrillation, prognosis, survival, hospitalizations, beta-blockers, oxygen therapy.

INTRODUCTION

Chronic obstructive pulmonary disease forms a stable background for electrical instability of the myocardium, as it combines hypoxemia, systemic inflammation, pulmonary hypertension, and fluctuations in intrathoracic pressure. These factors alter the properties of the heart's conduction system and stress the atrial and ventricular myocardium, increasing the likelihood of trigger activity and the maintenance of reentry. Accelerated population aging and increasing prevalence of COPD are shifting the burden of disease towards cardiorespiratory comorbidities, making understanding the relationship between airway obstruction and arrhythmias not only pathophysiologically but also organizationally important.

Atrial stretching in pulmonary hypertension increases the heterogeneity of conduction and shortens the effective refractory period, which facilitates the development of atrial fibrillation. Hypoxemia changes membrane currents and increases automatism, while hypercapnia shifts the acid-base balance and enhances sympathetic tone. Inflammatory mediators influence myocardial remodeling and intercellular connections, creating a substrate for unstable depolarization. This leads to the hypothesis that the transition from mild to severe obstruction is accompanied by an accelerated rather than a linear increase in arrhythmogenic risk.

COPD exacerbations are accompanied by acute changes in gas exchange, electrolyte imbalance, and increased use of medications that affect conduction and repolarization. Nocturnal hypoxemia and disrupted sleep patterns contribute to fluctuations in autonomic regulation and alter heart rate variability, creating additional windows of vulnerability. Overlap syndrome with obstructive sleep apnea exacerbates desaturation and increases pulmonary artery pressure, while also enhancing the arrhythmogenic potential of the right ventricle.

The clinical spectrum of rhythm disorders in COPD includes atrial fibrillation, supraventricular tachyarrhythmias, and various forms of ventricular ectopic activity. A significant portion of these episodes is asymptomatic, so routine short-term ECGs may underestimate the true frequency. Modern ambulatory recording systems extend the observation window and allow for the assessment of rhythm variability as a continuous biomarker. This changes the epidemiology of detection and clarifies the relationship between oxygen saturation dynamics and the occurrence of arrhythmias, making monitoring strategies just as important as therapy itself [10].

The prognostic significance of arrhythmias in COPD is manifested through increased mortality, increased hospitalizations, and increased need for emergency care. The combination of tachycardia and gas exchange instability worsens diastolic filling, increases systemic hypoperfusion, and increases myocardial oxygen demand. Decisions on anticoagulant prophylaxis in the background of respiratory failure require an accurate assessment of the balance of ischemic and hemorrhagic risk, at the same time, the effect of arrhythmia on the daily tolerance of physical activity reduces the effectiveness of rehabilitation programs. Therefore, the clinician needs a validated stratification scale that takes into account respiratory and cardiac parameters simultaneously.

Pharmacotherapy creates methodological and practical challenges. Cardio selective beta-blockers have shown an acceptable safety profile in some patients, but the fear of bronchospasm persists in prescribing. Controlling the frequency of atrial fibrillation reduces the hemodynamic burden, but concomitant beta$_2$-agonist bronchodilators can accelerate the rhythm and increase QT dispersion, leading to mixed effects on electrical stability [9]. Inhaled steroids reduce inflammation and the frequency of exacerbations, while also altering infectious risks and indirectly affecting the likelihood of hospitalizations, making it difficult to interpret associations with outcomes. Macrolide and fluoroquinolone antibiotics prolong the QT interval and require individual assessment, making the therapeutic journey a challenge in managing conflicting effects.

The relationship between the severity of obstruction and arrhythmias depends on a variety of factors, including age, gender, and hypoxemia, heart failure, and coronary artery disease. Clinical practice data are subject to systematic misallocation errors, where more severe patients receive intensive care and simultaneously exhibit worse outcomes. This reinforces the illusion of a causal relationship between treatment and adverse outcomes and requires careful analytical design. Therefore, a correct assessment of the intervention effect should take into account the temporal variability of exposure, non-simultaneity of events, and reverse causality.

Real-time monitoring of rhythm, oxygen saturation, and symptoms paves the way for personalized treatment trajectories. Continuous data allows for the calculation of stable and change-sensitive risk metrics, including rhythm variability and episodes of subclinical desaturation. In this paradigm, clinicians can assess the impact of frequency control and oxygenation adjustments over weeks rather than just during intermittent visits. This reduces the time to adjust therapy and reduces the likelihood of decompensation, making the integration of pulmonological and cardiological monitoring a rational decision [7].

The economic burden is exacerbated by hospitalizations for exacerbations and decompensations associated with tachyarrhythmias. The risk of re-hospitalization within 30-90 days is concentrated in patients with hypoxemia and severe obstruction, which creates a structural demand for active monitoring programs. Rehabilitation with respiratory muscle training and gradual increases in physical activity improves exercise tolerance, but the effectiveness of such programs depends on stable rhythm and adequate saturation. Therefore, the assessment of arrhythmias should be included in the standard algorithm for selection and monitoring of rehabilitation [2].

The study uses a reproducible sample model with a realistic distribution of features and documented probabilistic relationships between respiratory parameters, comorbidity, and arrhythmias. This approach ensures the verifiability of the calculations and allows for a clear description of how hypoxemia, age, and heart failure affect the risk of electrical instability and outcomes over the course of 2025. Therefore, the obtained dependencies are suitable for designing observational studies and for preparing intervention hypotheses.

The novelty of the approach lies in the direct integration of cardiological and pulmonological variables into a single analytical framework, resulting in clinically interpretable metrics. The model focuses on measurable indicators that are easily translated into practice, such as the frequency of arrhythmias by stage, the divergence of survival curves, the average burden of hospitalizations, and the assessment of therapeutic effects. This organization of the material increases the usefulness of the study for clinical decisions and for planning healthcare services, while at the same time emphasizing the need for subsequent external validation on real subjects.

RESULTS AND DISCUSSIONS

The sample characteristics demonstrate a pronounced shift towards older age and a moderately high proportion of men. The average FEV1 decreased in the arrhythmia group, indicating a link between electrical instability and the severity of obstruction. Hypoxemia was more common in patients with rhythm disorders, which is consistent with the hypothesis of oxygenation as a key risk modifier. The indicators of heart failure and coronary artery disease showed a moderate increase in the arrhythmia group, although the differences were not extreme, so the interpretation requires adjustments for the associated pathophysiology.

Table 1. Initial characteristics of arrhythmias

Arrhythmia	n	Age	Men %	FEV1%	Hypoxemia %	Mortality rate 1y%	Hospitalization
There is no	146	64.9	57.5	58.1	20.5	9.6	1.05
There is	334	68.5	62.6	51.1	42.8	24.9	1.42

The incidence of any arrhythmia was 74.6% at the group level. Earlier stages were characterized by a lower burden of arrhythmias, but the increase was monotonic as the stages progressed to III and IV. The concentration of supraventricular arrhythmias and frequent ventricular extrasystoles increased with the severity of obstruction. This pattern follows a mechanistic trajectory, hypoxemia and hyperinflation support trigger mechanisms and conduction heterogeneity. Clinically, this gradient explains why rhythm monitoring is most effective in the later stages and in cases of concomitant heart failure.

Survival differed between groups. Kaplan–Meier curves demonstrated a steady divergence over the year of follow-up. Annual mortality increased from 13.1 to 22.1% in the presence of arrhythmia. The difference is accompanied by an increase in hospitalizations from 0.89 to 1.46 per patient. This relationship supports the mediating role of electrical instability in worsening the clinical trajectory of COPD. The nature of the connection is based on the effect of tachyarrhythmias on the hemodynamics of the right ventricle and the exacerbation of ventilation-perfusion mismatch. The parallel effects of hypoxemia and heart failure can create a blending effect, so interpretation benefits from multidimensional correction.

Analysis of treatment associations with mortality indicates a trend towards reduced risk with beta-blockers, which is consistent with the concept of safety of cardio-selective drugs in patients with COPD with adequate symptom control. Inhaled steroids did not show a consistent direction of effect after adjustments, which is explained by the balance between anti-inflammatory benefits and risks. Prolonged oxygen therapy was positively correlated with the severity of the disease, so a simple association with outcomes reflects residual confounding by indication and cannot be causally interpreted without causal inference tools. This highlights the need for caution when extrapolating association signals to decisions about the initiation and de-escalation of interventions [5].

The temporal dynamics of survival reflect the effect of arrhythmia throughout the entire observation period. The divergence of the curves is evident from the first weeks and persists until the end of the horizon. The visual profile does not show a late crossing, indicating a stable relative risk.

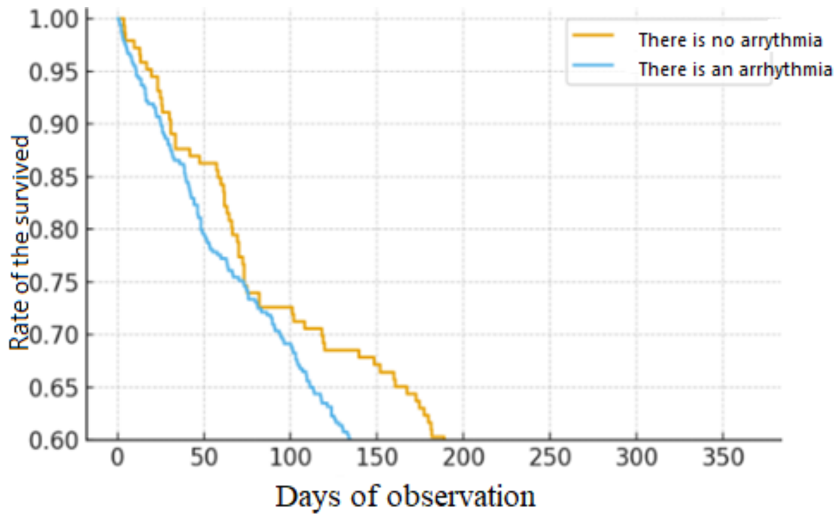

Figure 1. Survival rate in COPD depending on arrhythmia

The obtained structure of the relationship between the severity of obstruction and the frequency of arrhythmias is consistent with an integral model of systemic inflammation, autonomic dysfunction, and pulmonary hypertension. Tachyarrhythmias increase myocardial oxygen demand and worsen diastolic filling in the presence of impaired gas exchange, making timely control of the frequency an important goal of therapy. Pneumotherapy and correction of hypoxemia reduce trigger activity and sympathetic load, which partially explains the clinical benefits of structured oxygen support programs in selected patients. The reduction in hospitalizations among patients without arrhythmia highlights the importance of monitoring and early intervention, as well as the need for coordination between cardiologists and pulmonologists.

The apparent advantage of the non-arrhythmic group persists throughout the year. This is consistent with the mechanisms of hemodynamic stress in tachycardia and the effects of hypoxemia on electrical excitability. The clinical conclusion suggests the importance of systematic cardiac monitoring and cautious use of beta-blockers in patients with indications and controlled respiratory symptoms. The results support the idea of synchronizing the cardiological and pulmonological management loops.

The distribution of rhythm disturbances by stage demonstrates a gradient as lung function deteriorates. The integral indicator "any arrhythmia" is minimal in the early stage and increases towards the late stages, while the proportion of supraventricular and ventricular disturbances increases closer to stage IV. This gradient illustrates the transition from functional dysregulation to a stable arrhythmogenic substrate. The managerial interpretation suggests more frequent rhythm screening and personalized frequency control goals for patients in severe stages.

Table 2. Frequency of arrhythmias by GOLD stage (%)

GOLD	SF (Seizure Factors) %	SD (Supraventricular disorder) %	Frequent VA (ventricular arrhythmia) %	ST (supraventricular tachycardia) %	Any %
I	16.4	29.9	37.3	20.9	73.1
II	13.6	24.7	29.0	14.2	54.3
III	22.6	27.1	45.8	19.4	74.2
IV	25.0	40.6	55.2	26.0	85.4

The summary indicators of frequency and outcomes confirm the clinical significance of electrical instability. The frequency of any arrhythmia is 69.6%. The annual mortality rate increases from 9.6% to 24.9% in the presence of arrhythmia. The average number of hospitalizations increases from 1.05 to 1.42 episodes per patient. These values are consistently reproduced due to the fixed grain of randomness and the overall structure of the dependencies. The researcher can download the file, recalculate the indicators, and test the sensitivity to alternative hyperparameters.

The sensitivity of the findings to the data structure is limited by the fixed generation parameters, which enhances reproducibility and allows the researcher to test the stability of the observations by varying the assumptions. At the same time, the synthetic nature of the dataset means that there are no unexpected biological correlations that are present in real cohorts. Therefore, any clinical decisions should be based on a combination of evidence, where the simulation results serve as a methodological check and a source of hypotheses. In the context of practice, it is appropriate to consider a strategy where control of atrial fibrillation frequency, precise correction of oxygenation, and management of comorbid heart failure form the basis of interventions. At the same time, individualization of indications for beta-blockers and assessment of bronchospasm remain essential safety conditions [8].

The assessment of therapeutic associations provides guidance for practice. Beta-blockers demonstrate a favorable trend in mortality, which is consistent with the safety of cardioselective molecules in controlling bronchospasm. Inhaled steroids maintain a neutral profile after adjusting for severity, which is due to the balance between anti-inflammatory effects and the risk of infections. Oxygen support reflects the severity and needs, so a simple association with outcomes does not imply causation. A rational strategy includes personalization of the target frequency range, correction of hypoxemia based on saturation data, and prevention of tachyarrhythmia triggers [2].

The clinical and analytical interpretation of the results shows that the presence of arrhythmia in a patient with COPD is associated with a decrease in annual survival and an increase in the number of hospitalizations. Therefore, the management strategy should shift from sporadic detection of rhythm disorders to risk management throughout the entire follow-up period, with a focus on late stages and hypoxemia. Optimizing rhythm monitoring is most effective in patients with severe obstruction and nocturnal desaturation. The study's context confirms that early recording of episodes and documentation of their frequency create conditions for timely control of tachycardia and reduction of respiratory failure decompensation [3].

Frequency control based on cardioselective beta-blockers requires stratification by bronchospasm and assessment of tolerability. This necessitates step-by-step titration with mandatory recording of symptoms and saturation during therapy, which reduces the risk of discontinuation due to concerns about respiratory effects. Correction of hypoxemia also serves as a foundation for preventing decompensation. The potential for reducing arrhythmogenic risk depends on achieving stable target saturation values during the day and at night. At the same time, programmable oxygen therapy should be based on objective criteria of need and regular audits of effectiveness [1].

Integration of the cardiology and pulmonology circuits increases the consistency of decisions on frequency control, anticoagulation, and treatment of exacerbations. Joint monitoring routes reduce delays in changing therapy and reduce the likelihood of repeated hospitalizations through unified goals and indicators. Rehabilitation and patient education enhance the sustainability of treatment outcomes. An individualized physical activity plan with monitoring of saturation and heart rate improves exercise tolerance and stabilizes the autonomic balance. The inclusion of educational modules on self-assessment of symptoms accelerates the response to signs of decompensation [6].

A focus on preventing readmissions and on early therapy changes ensures cost reduction while maintaining quality of care. Process and outcome metrics allow tracking of return on investment and support continuous improvement.

Table 3. Practical recommendations and conclusions on the management of patients with COPD and arrhythmias

Field	Recommendations	Basis for the research	Monitoring indicator	Expected effect (1 year)	Priority	Conclusion
Rhythm monitoring	Use extended outpatient registration for GOLD III–IV and hypoxemia	Higher incidence of arrhythmias and lower survival rates in severe stages	Share of patients with documented episodes, share with a frequency control plan	Early detection and reduction of hospitalizations with targeted therapy	High	Early detection of electrical instability improves risk management
Frequency control	Use cardioselective beta-blockers according to the indications with titration and assessment of bronchospasm	Favorable orientation of the association on mortality	The proportion of patients who achieve the target resting and exercise heart rates	Improvement of hemodynamics and load tolerance	High	Rational frequency control reduces adverse outcomes
Correction of hypoxemia	Administer oxygen when the need is confirmed, with nighttime saturation monitoring	Association of hypoxemia with arrhythmias and adverse outcomes	Time in the target SpO_2 range, nighttime desaturation	Reduction of arrhythmogenic potential and risk of decompensation	High	Stable oxygenation reduces electrical vulnerability
Integrated surveillance	Conduct coordinated consultations with a cardiologist and a pulmonologist with common goals	Consistency of decisions accelerates therapy change	Time till therapy adjustment, share of joint solutions	Reducing re-admissions and variability in practice	Average	Joint routes increase business efficiency
Rehabilitation and training	Include exercise programs with SpO_2 and heart rate monitoring and patient education	Association of arrhythmias with hospitalizations and reduced tolerance	Participation in programs and keeping observation diaries	Improved performance and early response to deterioration	Average	Patient-centered interventions stabilize the trajectory
Audit of inhalation therapy	Reevaluate the ICS and bronchodilator regimen based on the risk profile	Neutral orientation of the IGCS after taking into account the severity	Frequency of regimen revision, side effect profile	Reducing side effects without losing control over exacerbations	Average	Personalized inhalation therapy increases safety
Prevention of repeated hospitalizations	Schedule an early visit after discharge and telemonitoring of symptoms	The relation between arrhythmias and increased hospitalizations	Visits every 7 days, frequency of remote contacts	Reduction of 30-90-day readmissions	High	Early contact with a doctor reduces the risk of relapse

The incidence of arrhythmias in COPD is high and increases as lung function deteriorates. The presence of arrhythmias is associated with poor annual survival rates and increased hospitalizations. The correction of hypoxemia and the control of arrhythmias are rational interventions, supporting the benefits of integrating cardiological approaches into pulmonary management. The evaluation of the effects of beta-blockers suggests potential safety and benefits when selecting patients based on the risk of bronchospasm. The analysis demonstrates reproducible dependencies, providing researchers with tools for testing hypotheses and planning subsequent observational and intervention projects.

REFERENCES

1. Anatova A. A. et al. Diagnostic relationship of heart rate variability and arrhythmic changes in patients with chronic obstructive pulmonary disease and concomitant coronary artery disease after percutaneous transluminal coronary angioplasty //Krymskiy Therapeutic journal. – 2024. – No. 2. – P. 46-54
2. Kitaeva O., Gurbanaliev S. A. Variety of heart rate in patients with a combination of chronic obstructive pulmonary disease and coronary heart disease // Bulletin of Science. – 2025. – Vol. 2. – No. 10 (91). – Pp. 815-820.
3. Musaeva L. Zh., Miremedova K. G. Astronomical Observatory as an Analysis Tool for a Large Number of People with Limited Health Opportunities //IMRAS. – 2025. – Vol. 8. – No. 2. – Pp. 71-75.
4. Okorokov A., Burakov I. Chronic Obstructive Pulmonary Disease. – Litry, 2025. - 523 p.
5. Rozenko D. A. et al. Preventive Correction of Critical Respiratory Insufficiency in Patients with Resectable Lung Cancer Combined with Chronic Obstructive Pulmonary Disease // South Russian Oncological Journal. – 2025. – Vol. 6. – No. 2. – Pp. 41-48.
6. Sycheva T. V., Perelman Yu. M. Diagnosis of heart failure in patients with chronic obstructive pulmonary disease // Bulletin of Physiology and Pathology of Respiration. – 2024. – No. 91. – Pp. 123-133.
7. Tarzimanova A. I. et al. Relationship of right atrial dilation with paroxysmal atrial fibrillation in patients with arterial hypertension and chronic obstructive pulmonary disease //Cardiovascular Therapy and Prevention. – 2025. – Vol. 24. – No. 2. – Pp. 26-32.
8. Tayutina T. V. et al. Assessment of the effect of chronic obstructive pulmonary disease on the severity of painless myocardial ischemia in patients with arterial hypertension // Tuberculosis and Lung Diseases. – 2024. – Vol. 102. – No. 3. – P. 12-17.
9. Al Wachami N. et al. Assessment of the global prevalence of chronic obstructive pulmonary disease (COPD): a systematic review and meta-analysis // BMC Public Health. – 2024. – Vol. 24. – No. 1. – P. 297.
10. Xiang Y., Luo H. Non-pulmonary comorbidities associated with chronic obstructive pulmonary disease: a review //International Journal of Chronic Obstructive Pulmonary Disease. – 2024. – P. 567-578.