Int. J. Curr. Res. Med. Sci. (2025). 11(6): 40–54

International Journal of Current Research in Medical Sciences

ISSN: 2454-5716

(A Peer Reviewed, Indexed and Open Access Journal)

www.ijcrims.com

Review Article

Volume 11, Issue 6 -2025

DOI: http://dx.doi.org/10.22192/ijcrms.2025.11.06.004

A review on COPD and efficacy and safety challenges of nebulization treatment in COPD management

Tamilselvam K[1], Mr. M. Immanuel Jebastine[2], Dr. K. Karthickeyan[3], Dr. P. Shanmuga Sundaram[4]

[1]M.pharm II year, Department of Pharmacy Practice, School of Pharmaceutical Sciences, VISTAS.

[2]M.Pharm, (Ph.D), Assistant Professor, Department of Pharmacy Practice, School of Pharmaceutical Sciences, VISTAS.

[3]Professor and Head, Department of Pharmacy Practice, School of Pharmaceutical Sciences, VISTAS

[4]Dean, department of Pharmaceutical Sciences, VISTAS

Corresponding Author: Tamilselvam K

M. Pharm II year, Department of Pharmacy Practice, School of Pharmaceutical Sciences, VISTAS.

E-mail: *tamilselvamtsk03@gmail.com*

Abstract

Chronic obstructive pulmonary disease is a progressive deteriorative respiratory disease characterized by an airflow limitation and chronic respiratory symptoms, it has been proved to affect significantly the quality of life of patients and constitute a burden on the healthcare system globally. Proper management is very vital as it improves the quality of life, minimizes symptoms and exacerbations, and improves the treatment. Among many types of therapy, nebulized therapy has become popular because of its direct delivery of the medication by the lungs to patients who have severe airflow limitation or poor inhalation techniques. This review will thus encompass details about the pathophysiology, diagnosis, and treatment strategies concerning the chronic obstructive pulmonary disease with special emphasis on nebulization therapy. Clinical effectiveness, patient compliance, and safety profile of nebulized bronchodilators and steroids have been reviewed. It has also covered some of the main problems linked to devices, technique, side effects, and possible infection risks. Clear mention has also been made regarding the need for individualized treatment approach, education, and careful follow-ups so as to maximize the therapeutic benefits but minimize complications in which COPD patients undergoing nebulization therapy might experience.

Keywords: Chronic Obstructive Pulmonary Disease (COPD), Nebulization Therapy, Bronchodilators, Inhalation Devices, Safety Challenges, Drug Delivery, Respiratory Disorders, Patient Compliance, Exacerbation Management, Aerosol Therapy

Introduction

Chronic Obstructive Pulmonary Disease (COPD), a type of respiratory illness, has been defined as an irreversible and worsening airflow limitation associated with chronic respiratory symptoms. It has become an important global health problem by adding considerably to morbidity, mortality, and health costs around the world. Importantly, the disease has been caused by exposure to noxious gases and particulate matter, particularly tobacco smoke, but also environmental pollution and occupational exposures.

As declared by the Global Initiative for Chronic Obstructive Lung Disease (GOLD), "This is a disease that is common and preventable and treatable: characterized by the presence of respiratory symptoms and airflow limitation due to airway and/or alveolar abnormalities usually caused by significant exposure to noxious particles or gases." [1,2]

Types of COPD

1. Chronic Bronchitis

Chronic bronchitis, which is marked by cough and excessive mucus production for at least three months during two consecutive years, is due to long-term irritation and inflammation of the bronchi, leading to narrowing of the airways, mucus accumulation, and increased susceptibility to infections. Main symptoms are productive cough, wheezing, and repeated respiratory infections.

2. Emphysema

The condition known as emphysema involves the destruction of lung alveoli (air sacs), which results in defective gas exchange and a diminished oxygen supply to the body. The loss of elasticity of the alveolar walls leads to air trapping and difficulty with expiration. Patients complain of shortness of breath (dyspnea), of a barrel-like shape to the thoracic cavity, and are usually underweight due to increased effort in breathing.

3. Mixed COPD (Overlap Syndrome)

Mixed presentations arise in some patients who demonstrate features of both chronic bronchitis and emphysema. Overlap syndrome results in added severity of airflow limitation, exacerbations, and progression of disease as compared to isolated forms.[3]

Causes/Etiology of COPD [4]

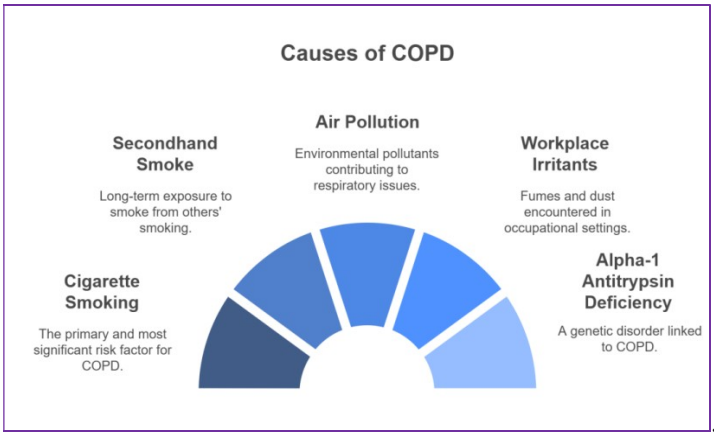

Figure 3: Causes of COPD

Epidemology of COPD

Chronic Obstructive Pulmonary Disease is a serious health problem of the world. According to estimates, it is the third major killer disease: it causes about 3.23 million deaths, annually. The world's COPD prevalence is estimated at 10% among adults aged over 40 years. These figures

differ according to geographic areas, socioeconomic aspects, and different risks exposures. Low and middle-income countries report almost nine deaths of every ten that occur in this context. Much of this is due to increased exposure to indoor air pollution, occupational exposure, and inadequate healthcare access.

Several major causes of increasing COPD burden in India can be cited: a rise in the number of cases from 28 million in 1990 to 55 million in 2016. The estimated prevalence among adults in India is 7.4% and is more prevalent among males, in urban areas, and northern regions. With the disease contributing to more than 500,000 deaths annually, India has among the highest rates of COPD mortality in the world.[5]

The risk factors include tobacco smoking (40-70% of new cases), exposure to smoke produced by burning biomass fuel (3 billion people worldwide), and workplace pollutants, with dust and chemical agents being some of the most common. Although smoking has decreased in some countries, increasing levels of ambient pollution and an aging population have contributed to an increased burden of COPD. Increased morbidity, frequent hospitalization, and high economic costs characterize COPD. The disease is responsible for more than 3 million hospital admissions worldwide per year and costs more than $50 billion annually in healthcare expenditure in the United States alone. As the pattern of aging continues apace among world populations, and risk factors in the environment remain constant, there is an expected rise in prevalence and morbidity of COPD. This trend will require, in addition to early detection and management, an effective prevention strategy.[6,7,8]

Pathogenisis of COPD

Exposure to Noxious Agents

Long-term exposure to noxious gases and particles has also led to the incidence of COPD. The predominant causative agents are smoke inhalation from cigarettes, burning biomass fuels, ambient air pollution, and occupational dust exposure. These irritants initiate an inflammatory response in the lungs that results in structural and functional deterioration over time. Smoking is the major risk factor, with about 85-90% of COPD cases worldwide attributable to it.

Chronic Inflammation

Airway inflammation becomes chronic after inhalation of toxins, involving immune cells such as macrophages, neutrophils, and CD8+ T lymphocytes. The latter secrete inflammatory mediators such as tumor necrosis factor-alpha (TNF-α), interleukins (IL-8), and MMPs, which act to the detriment of lung tissue. The chronic inflammation then engenders airway remodeling and destruction of lung parenchyma and mucus hypersecretion, thus contributing to progressive airflow limitation.[9,10]

Oxidative Stress and Protease-Antiprotease Imbalance

Oxidative stress serves as the main reason component involved in the pathogenesis of COPD. The generation of reactive oxygen species (ROS) from cigarette smoke or inflammatory processes leads to lung injury. DNA damage, protein oxidation, and apoptosis are made possible by oxidative stress. There is also disruption of the protease: antiprotease balance, with proteases destroying lung tissue while antiproteases protect lung integrity. Proteases are increased in activity, particularly neutrophil elastase and MMPs, yielding destruction of alveolar walls, leading to emphysema.

Structural Changes in the Lungs

Loss of normal structural integrity in the lungs that would be considered irreversible is in fact a characteristic aspect of COPD, including emphysema, small airway remodeling, and chronic bronchitis. In emphysema, first, alveolar wall destruction leads to loss of elastic recoil of the lung and causes problems of air trapping and hyperinflation. Second, remodeling of small airways would involve fibrotic changes along with narrowing of the bronchioles, which further impedes airflow. Chronic bronchitis is

characterized by prolonged mucus hypersecretion and inflammation of the airways, culminating in chronic cough and increasing susceptibility to infections.

Airflow Limitation and Gas Exchange Impairment

Long-term progressive injury to the lungs produces marked airflow limitation whereby air is both somewhat impeded from entering and obstructed from exiting the lungs easily. Destruction of the alveolar walls results in mismatching of ventilation and perfusion (V/Q) and, thus, hypoxia (low levels of oxygen) and hypercapnia (high levels of carbon dioxide). This impairment in gas.

Systemic Effects of COPD

The other systems affected by COPD include those are due to generalized chronic inflammation and hypoxia. Muscle loss, weight loss, and impaired exercise tolerance are other common symptoms that patients experience. Systemic inflammation caused by COPD also presents the risk of developing cardiovascular diseases like hypertension, heart failure, and atherosclerosis. Metabolic impairments such as osteoporosis and insulin resistance are also quite prevalent among patients with COPD. Another psychological condition such as anxiety and depression affects quality of life. [11,12]

Symptoms of COPD[13,14,15,16]

Symptoms	Emphysema ("Pink Puffers")	Chronic Bronchitis ("Blue Bloaters")
Cough	Minimal or dry cough	Persistent, productive cough with thick mucus
Sputum Production	Scanty or absent	Excessive mucus production
Shortness of Breath (Dyspnea)	Severe, progressive, even at rest	Mild to moderate, worsens over time
Wheezing	May occur occasionally	Frequent wheezing and crackles
Chest Tightness	Common	Common
Cyanosis (Bluish Skin/Lips)	Less common (adequate oxygenation)	Common (low oxygen levels)
Weight Changes	Weight loss and muscle wasting	Weight gain due to fluid retention
Barrel Chest	Present (due to hyperinflation)	Not typically present
Edema (Swelling in Legs/Ankles)	Rare	Common (due to right-sided heart failure)

Diagnosis of COPD

1. Medical History and Clinical Assessment

Diagnosis of COPD commences with a very detailed history for symptoms like cough- chronic cough or sputum production or breathlessness, shortness of breath, and wheezing. Risk factors are also checked for smoking, occupational exposures, and family history of lung disease. Reports on progressive dyspnea, recurrent respiratory infections, and exercise intolerance are common..

2. Physical Examination

Prolonged expiration, wheezing, decreased breath sounds, and hyperinflation of the chest can sometimes be detected during examinations. In the late stages, cyanosis (a bluish tint of the skin), use of accessory muscles for breathing, and ankle swelling due to corpulmonale (right-sided heart failure) may develop.

3. Spirometry (Pulmonary Function Test - PFTs)

Spirometry is the standard test for making a diagnosis of COPD. It assesses the function of the lungs with measures of the forced expiratory volume in one second (FEV_1) and the forced vital capacity (FVC). Once again, a post-bronchodilator FEV_1/FVC ratio of < 0.70 confirms persistent airflow limitation, which is a signature feature of COPD. Severity can be further classified within grades based on the percentage of the predicted FEV_1.

4. Imaging Studies (Chest X-ray and CT Scan)

While a chest X-ray may rule out other lung disorders, such as pneumonia or lung cancer, it might reveal hyperinflation, flattened diaphragms, or emphysematous changes. A high-resolution CT scan gives clear pictures of the lung structure and specifically detects emphysema and bullous lung disease.

5. Arterial Blood Gas (ABG) Analysis

When the COPD is moderate to severe, we use ABG to assess the oxygen (PaO_2) and carbon dioxide ($PaCO_2$) levels in the blood. Patients with chronic COPD can form respiratory acidosis due to CO2 retention, reflecting inadequate ventilation. This test is vital for deciding whether long-term oxygen therapy is indicated.

6. Alpha-1 Antitrypsin (AAT) Deficiency Testing

Testing for AAT deficiency is warranted if the patient is quite young (younger than 45 years) or if there is a strong family history of COPD. AAT deficiency is an inherited condition leading to early development of emphysema due mainly in non-smokers.

7. Exacerbation Assessment

Frequent exacerbations are important in COPD progression and worsened prognosis. Exacerbation risk assessment incorporates factors such as severity of symptoms, prior hospitalizations, use of bronchodilators, and any associated infections.

8. Electrocardiogram (ECG) and Echocardiography

COPD could also include pulmonary hypertension with right-sided heart failure (corpulmonale). An ECG may reveal enlargement of the right atrium, right ventricular hypertrophy, or arrhythmias. In doubtful cases of heart involvement, echocardiography evaluates pulmonary artery pressures and cardiac function. [17,18,19]

Treatment

Regarding the treatment of chronic obstructive pulmonary disease (COPD), it has been found that patients receive the following interventions: symptom reduction, lung function improvement, exacerbation prevention, and enhancement of the quality of life. Such an approach may include smoking cessation and the use of pharmacological and oxygen therapies as well as non-pharmacological interventions with surgical options in the most severe cases.

Smoking Cessation

In COPD management, the most important of interventions is, therefore, smoking cessation; it has a major positive effect in delaying disease progression. Commonly used smoking cessation interventions include counseling, nicotine replacement therapies (NRTs), and medications like varenicline or bupropion. Combination treatment using both drugs and counseling improves the chances of maintaining abstinence in the long term.[20,2]]

Pharmacological Therapy

The management of COPD symptoms with medications essentially improves airflow and reduces inflammation and disease progression. First, bronchodilators in the short of acting variety (SABA), such as salbutamol, and the long-acting beta-agonists (LABA) include salmeterol for the treatment of COPD. Anticholinergics are

available in short-acting, such as ipratropium, or long-acting, like tiotropium, with the same effect of bronchodilation. Inhaled corticosteroids, or ICS, such as budesonide or fluticasone,are administered to patients with frequent exacerbations and are often combined with bronchodilators. Phosphodiesterase-4 inhibitors like roflumilast greatly reduce exacerbations in patients with chronic bronchitis.

Oxygen Therapy

Long-term oxygen therapy is indicated for those COPD patients who suffer from chronic hypoxemia ($PaO_2 \leq 55$ mmHg or $SaO_2 \leq 88\%$). Oxygen therapy prolongs life, decreases hospitalizations, and improves the overall quality of life in individuals with a severe illness. It's indicated in patients with respiratory failure or patients who undergo considerable oxygen desaturation during sleep or exertion.[22,23,24]

Non-Pharmacological Interventions

Pulmonary rehabilitation, which houses exercise training, nutritional consultation, and patient education, improves functional capacity with decreased breathlessness. Breathing exercises, like pursed-lip breathing, aid managing shortness of breath. Influenza and pneumococcal vaccination prevents respiratory infection from aggravating COPD symptoms. Nutritional support is also important, as it is related to bad outcomes. Nutrition may improve muscle function and be involved in immunity.

Management of Acute Exacerbations

COPD exacerbations have some distinguishable characteristics, the first being sudden worsening of the symptoms, mostly needing prompt medical intervention. They use short-acting bronchodilators to get immediate symptom relief, such as SABAs or short-acting muscarinic antagonists (SAMAs). Oral corticosteroids like prednisolone (40 mg for 5 days) help reduce inflammation and hasten recovery. If there is a suspicion of bacterial infection, then appropriate antibiotics such as amoxicillin, azithromycin, or levofloxacin can be added. The individual may require hospitalization for severe breathing difficulties or oxygen levels dropping during exacerbation.

Surgical Interventions

Such advanced stages of COPD render the entire surgical options like Lung volume reduction surgery (LVRS), bullectomy, and lung transplantation for such cases. LVRS is a surgical resection of the damaged lung tissue responsible for poor breathing efficiency, whereas lung transplantation becomes an option for an end-stage COPD patient who is much younger. [25,26,27]

Classification of drugs

Drug Class	Examples
Short-Acting Beta-Agonists (SABAs)	Salbutamol, Levalbuterol
Short-Acting Muscarinic Antagonists (SAMAs)	Ipratropium bromide
Long-Acting Beta-Agonists (LABAs)	Salmeterol, Formoterol, Indacaterol
Long-Acting Muscarinic Antagonists (LAMAs)	Tiotropium, Umeclidinium, Glycopyrronium
Inhaled Corticosteroids (ICS)	Budesonide, Fluticasone, Beclometasone
Combination Therapy (LABA + LAMA)	Indacaterol + Glycopyrronium, Vilanterol + Umeclidinium
Combination Therapy (LABA + ICS)	Salmeterol + Fluticasone, Formoterol + Budesonide

Triple Therapy (LABA + LAMA + ICS)	Vilanterol + Umeclidinium + Fluticasone
Phosphodiesterase-4 Inhibitors (PDE-4 Inhibitors)	Roflumilast
Methylxanthines	Theophylline, Aminophylline
Mucolytics and Expectorants	N-acetylcysteine, Erdosteine
Systemic Corticosteroids	Prednisolone, Methylprednisolone
Antibiotics (for infections/exacerbations)	Amoxicillin, Azithromycin, Levofloxacin
Oxygen Therapy	Supplemental oxygen

Complications

Complication	Description
Respiratory Failure	When there is inadequate gas exchange, hypoxemia and hypercapnia result. Usually the patients may requires oxygen therapy or ventilation.
Pulmonary Hypertension	Increased pressure in the pulmonary arteries due to chronic hypoxia puts a strain on the heart.
CorPulmonale (Right Heart Failure)	The right ventricle becomes enlarged and fails due to pulmonary hypertension.
Frequent Respiratory Infections	The other major cause would be increased susceptibility to pneumonia, bronchitis, and influenza due to mucus accumulation and inadequate defense of the lungs
Acute Exacerbations	An acute episode of worsening of breathlessness, cough, and sputum production occurs, often triggered by infections or pollution
Pneumothorax (Collapsed Lung)	Rupture of airspaces or bullae with air leak, sudden onset with chest pain, and dyspnoea.
Osteoporosis & Muscle Wasting	Long-term steroid use and chronic inflammation lead to increases in the risk of developing weak bones and muscle loss
Sleep Disorders	Factors such as sleep apnea and insomnia worsen fatigue and cardiovascular health.[28,29]

Nebulization therapy

Nebulization therapy is a form of inhalation treatment quite popular for respiratory diseases like chronic obstructive pulmonary disease (COPD) and asthma. The principle of nebulization includes the conversion of liquid medication into an aerosol mist that is inhaled directly into the lungs. It permits quick drug delivery and consequently improves the drug effect. The use of nebulizers thus becomes more important in the case of a patient with severe airflow obstruction, the elderly, and patients who cannot coordinate metered-dose inhalers (MDIs) or dry powder inhalers (DPIs) well.[30,31]

Types of Nebulizers

1. Jet Nebulizers : Jet nebulizers are the most frequently employed type of nebulizers, which operate with the principle of using compressed air to convert liquid medication to an inhalable mist. They are reasonable and can be used for several medications. However, they are bulky, require external power sources, and use longer times during medication delivery.

2. Ultrasonic Nebulizers : The ultrasonic nebulizer is, through the use of high-frequency sound waves, capable of providing aerosolized medication. This denser concentration of aerosol fine droplets produced is more uniform and smaller in size to be able to penetrate deeper into the lung for faster drug delivery. An ultrasonic nebulizer is quiet and highly efficient compared to a jet nebulizer but is not for use with all medications since it is unsuitable for a heat-sensitive drug. Higher in cost, additional care and maintenance are necessary to avoid clogging and ensure that the medication is dispersed properly.

3. Mesh Nebulizers : Fine mist generation in mesh nebulizers involves the use of a vibrating mesh, thereby ensuring efficient drug delivery with minimal drug wastage. Point-of-care; portable, and silent, they are ideally suited for home and travel use. Compared to jet and ultrasonic nebulizers, they are faster and more effective in delivering the medication. Above all, mesh nebulizers are costly, most cleaning must be carried out to prevent clogging, and the maintenance costs can be high, resulting in limited utilization.[32,33]

Medications Used in Nebulization Therapy

Nebulizers are used to administer a variety of medications, including:

- **Bronchodilators** (e.g., Salbutamol, Ipratropium) – Help relax airway muscles and improve breathing.
- **Corticosteroids** (e.g., Budesonide, Fluticasone) – Reduce inflammation and prevent exacerbations.
- **Antibiotics** (e.g., Tobramycin) – Used in respiratory infections, particularly in cystic fibrosis.
- **Mucolytics** (e.g., N-Acetylcysteine) – Help in clearing mucus from the airways.[34]

Nebulization Technique Challenges

Though nebulization therapy is beneficial, a number of hurdles limit the full-use of this technique. Patient adherence problems caused by a lack of training, patients not properly sealing the mask and not holding the mask according to the correct breathing technique.Device-associated problems includes patient struggling to nebulizer cleanings, which may be a significant source of contamination. Furthermore,there is difficulty with the assembly and functioning of the nebulizer, which affects treatment efficacy. Regular use of an electrical device becomes more problematic in terms of noise levels. Thus, the patient education, modification of devices, and health care professionals have to intervene in overcoming these barriers for better effectiveness and adherence.

1. Improper Mask Sealing: Improper mask sealing presents a major problem in nebulization therapy in 32% of patients. A leaky fit allows medication to escape back and reduces lung drug deposition, diminishing treatment efficacy. Proper patient education about the mask adjustment for fit with the patient could improve drug delivery and overall therapeutic outcome.

2. Incorrect Breathing Technique : At least 25% of patients do not follow the correct breathing pattern with a nebulizer, resulting in reduced drug absorption. With irregular or shallow breathing, there is reduced deposition of the drug in the lower airways. Slow, deep breaths and breath-holding may improve drug delivery and efficacy of treatment.[35,36]

3. Nebulizer Cleaning and Maintenance Issues: Nebulizer cleaning issues are encountered by a few patients, which in turn can cause bacterial contamination, ambience for respiratory infections, and improper nebulization caused by medication buildup in the nebulizer. Cleaning your nebulizer with sterile water and properly

drying it are essential, as it prevents infection and ensures consistent drug delivery to the patient.

4. Difficulty in Assembly and Operation : There are few patients who can put up the nebulizer and operate it properly. It can be set that incorrect assembly will lead to leaking, poor drug delivery efficiency, and damage to the device. A simpler design, some instructional videos, and help from health care practitioners will empower patients and convince them about proper use.

5. Power Dependency and Noise Issues : Electric nebulizers depend on a source of power supply for their operations, which makes them difficult to use in places travelling or mainly those that regularly face power interruption or blackout. Besides, noisy compressor-based nebulizers cause discomfort, especially in between young children and old patients. Battery and ultrasound nebulizers offer a quiet and portable alternative to ensure better compliance and comfort among patients.[37,38]

6. Medication Wastage and Residual Volume : Drugs that are not being completely delivered damage some patients since they mostly occur as residual drugs in the chamber of the nebulizer. This causes non-optimal dosing and may result in an increase in treatment costs. Therefore, if nebulizers with low remaining medication volumes are used together with a proper inhalation technique, drug utilization should be increased.

7. Duration of Nebulization: Typically nebulization sessions last between 10 and 15 minutes and are therefore inconvenient for some patients, resulting in noncompliance. This can prove particularly inconvenient for busy or impatient patients. Speeding up a nebulizer and arranging therapy sessions appropriately would elicit greater compliance and satisfaction from patients.

8. Inconsistent Drug Delivery: Incorrect positioning of the device or other variations in nebulization output affect the consistency of medication. Certain factors govern drug delivery, such as inhalation flow rate and nebulizer type. Patient education on the need for holding the device upright and, if applicable, the use of breath-operated nebulizers will enhance treatment effectiveness.

9. Coordination Issues in Elderly and Pediatric Patients : In case of nebulization therapy, elderly patients and young children may not have adequate coordination resulting in less uptake of the drug into the lungs. This is prominent in 14% of cases where cognitive and physical impairment may prevent the proper use of the device. Drug administration might be improved by training the caregivers to administer the drug via an adequately sized facemask.

10. Cost and Accessibility of Nebulization Therapy : The equipment's costs, medications, and accessories nebulization-however little-affects a few patients, particularly those from lower-income strata. Limited access to nebulization therapy in the rural context has further adverse effects on treatment outcomes. Availability of low-cost devices, insurance coverage, and community healthcare programs can go a long way in improving accessibility and, therefore, adherence.[39,40]

Efficacy of Nebulization therapy

1. Rapid Symptom Relief :The nebulization therapy gets medications into the lungs th fastest from all routes. It provides immediate bronchodilation in airflow reactive symptoms such as shortness of breath, wheezing, and chest tightness, especially during exacerbation of acute COPD and asthma.

2. Enhanced Drug Deposition in the Lungs: The drugs are nebulized to prevent their being destroyed on the digestive route and to ensure a better deep lung penetration. Thus, the local concentration of the drug gets enhanced, thereby improving its therapeutic efficacy in diseases in which drug delivery is considered vital: bronchiolitis, pneumonia, and cystic fibrosis.

3. Improved Pulmonary Function :Current studies reported improvement in lung function as nebulization therapy increases FEV1 (Forced

Expiratory Volume in 1 s) and FVC (Forced Vital Capacity). Repeated nebulization reduces airway resistance; therefore, these techniques facilitate breathing in patients with COPD and asthma.

4. Reduction in Hospitalization Rates :The timely nebulization therapy in turn provides a way out of severe respiratory distress and emergency admissions into hospitals. It is a huge help for patients suffering from chronic lung problems since proper home management reduces complication risks and improves long-term outcomes.

5. Consistent Drug Absorption: Nebulization therapy offers a more even and consistent delivery of medicine into the patient's system, with no requirement for coordination at the time of using the nebulizer, unlike inhalers.Moreover, it will be more beneficial for elderly patients and patients who have neuromuscular disorders in ensuring proper medicine intake.[41,42]

6. Long-Term Disease Management: Frequent nebulization therapy in chronic diseases like COPD, asthma, and bronchiectasis ensures a stable respiratory function. It lessens the frequency of exacerbation and improves quality of life by relieving respiratory distress and the frequency of interventions.

7. Effective in Severe Cases :In severe respiratory conditions in which patients are incapable of adequately using inhalers, nebulization is preferred therapy. In intensive care units and emergency settings, it is widely used in stabilizing critically ill patients in acute lung failure.

8. Superior Mucus Clearance :Nebulized mucolytics and bronchodilators enable the patients to loosen thick mucus secretions, which are then easily expectorated. This helps to maintain airway patency and improve oxygenation in patients suffering from chronic bronchi-tis, cystic fibrosis, and pneumonia.

9. Minimized Systemic Side Effects :Since the nebulized medications act locally in the lungs, they will have lesser systemic absorption, hence reducing side effects such as tachycardia, hypertension, and gastrointestinal issues, which are highly expected with oral or intravenous therapy.

10. Adaptability for Combination Therapy: Several drugs, bronchodilators, corticosteroids, and antibiotics can be nebulized at the same time, thus optimizing symptom control and treatment effectiveness in complicated respiratory conditions.[43,44]

Safety challenges in Nebulization therapy

1. Risk of Contamination : Under poor hygiene conditions, nebulizer chambers, masks, and tubing may harbor bacteria and fungi, posing respiratory diseases, particularly in immunocompromised patients or those suffering from chronic lung diseases such as COPD and cystic fibrosis.

2. Incorrect Drug Dosage: In contrast to the inhalers, nebulization therapy calls for narrow dosing-regimens. An overdose may give rise to systemic side effects like tachycardia, tremors, and hypertension, and an underdose results in intolerable symptom relief. Subsequently, such a path worsens respiratory conditions.

3. Device Maintenance Issues : For a nebulizer to operate efficiently and effectively, regular cleaning and replacement of parts are very important. Malfunctioning devices can either deliver too high or too low amounts of medication, which would compromise their therapeutic effectiveness and subsequently their efficacy on the patient.

4. Prolonged Treatment Time: Nebulization usually takes longer time for actual patient use than for an inhaler; this is typically rounded off to an estimate of10-15 minutes per session. This would act as a hurdle to patient adherence especially to patients who live busy lifestyles or find it quite uncomfortable using a nebulizer mask.[45,46]

5. Airborne Drug Exposure : Medication aerosols can disperse into the surrounding air,

posing risks to caregivers and nearby individuals. This is particularly concerning in hospital settings, where corticosteroids or antibiotics may cause unintended exposure and side effects.

6. Improper Inhalation Technique :Slow and deep breathing is essential for the ideal delivery of medications into the lungs. Shallow breathing, safe talk, and inappropriate mask positions reduce drug deposits in the lungs, thus compromising their therapeutic effect.

7. Compatibility Issues with Medications :These medications when nebulized may not prove to be compatible with each other. For example, corticosteroids and bronchodilators amongst other medications may produce reduced efficacy or more side effects when mixed. Therefore, prescriptions should be done with great precision by health care professionals.

8. Side Effects from Long-Term Use : Contraindications to chronic therapy nebulization, especially when using corticosteroids or bronchodilators, include oral candidiasis/thrush, hoarseness, throat irritation, and various side effects that enter the systemic circulation such as osteoporosis, hyperglycemia, or adrenal suppression.

9. Dependency and Overuse :Psychological dependence on nebulization may develop in some patients who may use it unnecessarily or excessively, thus impairing natural lung function recovery and fostering drug resistance with the passage of time.

10. Limited Portability and Power Dependency :Unlike inhalers, nebulizers are devices that require a stable source of environmental stimulation that could limit a person's mobility in quite a number of cases such as travelling or emergencies. Battery-operated nebulizers are available but might not work as efficiently as the standard electric nebulizers.[47,48]

Nebulization technique assessment

Evaluating the nebulization technique is important in order to achieve optimum drug delivery and therapeutic benefit in people with COPD. This assessment should include inhalation technique and breathing pattern, device handling and maintenance. Common mistakes include: incorrect assembly of the device, insufficient inhales depth, or forgetting to clean the nebulizer. This will lead to reduced deposition of drug in the lungs. Regular education and reassessments on the use of techniques to patients have been shown to make better adherence and, thus, indexed treatment outcomes in terms of reduction of exacerbations and hospitalization. A health care provider can create routine evaluations for patients using checklist and demonstration to make possible the identification of errors and corrective measures for them to secure maximum drug effects and better lung function in COPD management at the end of the day.[55]

Nebulization Technique Assessment Questionnaire

Question	Response Options
Do you wash your hands before handling the nebulizer?	Yes / No
Do you correctly assemble the nebulizer parts before use?	Yes / No
Do you use the prescribed medication with the correct dosage?	Yes / No
Do you maintain an upright, comfortable posture during nebulization?	Yes / No
Do you ensure a tight seal with the mouthpiece or mask?	Yes / No
Do you practice slow, deep breathing during inhalation?	Yes / No
Do you complete the full duration of medication inhalation?	Yes / No
Do you clean and maintain the nebulizer after each use?	Yes / No
Do you avoid talking or removing the mask during therapy?	Yes / No
Do you store the nebulizer and medications in a clean, dry place?	Yes / No

Figure12: Nebulization Technique Assessment Questionnaire

Score (Number of "Yes" Responses)	Interpretation
9 – 10	Good Technique – Proper adherence to nebulization steps, ensuring optimal drug delivery and treatment effectiveness.
6 – 8	Needs Improvement – Some errors in technique that may reduce therapeutic efficacy; patient education and retraining are recommended.
≤ 5	Poor Technique – Major issues in nebulization use, leading to ineffective treatment; requires immediate retraining and supervision.

Figure13:Nebulization Technique Assessment Interpretation

Conclusion

Chronic Obstructive Pulmonary Disease (COPD) constitutes a massive public health concern, even chronicity combined with increasing prevalence and substantial morbidity and mortality. Therefore, such a complex condition requires a multipronged approach: from medicines to other life realization changes, to patient education. And crucial for this reason in nebulization therapy is an effective therapy for poor coordination, low inspiratory flow rates, and patients who have a high disease severity. Nebulized medications are beneficial mostly in terms of drug administration and symptom relief. However, disadvantages include device handling, infection risk, and patient adherence. Customized treatment strategies, proper patient counseling, and close monitoring will optimize the efficacy and safety of nebulized therapy in COPD. Future advances in research and innovation on inhalation devices will thus be paradigmatic in the improvement of patient outcomes and the delivery of most patient-centered health care services across the board in COPD management.

References

1. Agarwal AK, Raja A, Brown BD. Chronic Obstructive Pulmonary Disease. 2022
2. COPD: Causes, Symptoms, Diagnosis, Treatment & Prevention https://my.clevelandclinic.org/health/diseases/8709-chronic-obstructive-pulmonary-disease-copd
3. Mejza F, Gnatiuc L, Buist AS, Vollmer WM, Lamprecht B, Obaseki DO, Nastalek P, Nizankowska-Mogilnicka E, Burney PGJ; BOLD collaborators; BOLD study collaborators. Prevalence and burden of chronic bronchitis symptoms: results from the BOLD study. EurRespir J. 2017 Nov 22;50(5):1700621.
4. Chronic Obstructive Pulmonary Disease https://www.who.int/news-room/fact-sheets/detail/chronic-obstructive-pulmonary-disease-(copd)
5. G. Viegi, F. Pistelli, D.L. Sherrill, S. Maio. Definition, epidemiology and natural history of COPD. 2007.
6. Verma A, Gudi N, Yadav UN, Roy MP, Mahmood A, Nagaraja R, Nayak P. Prevalence of COPD among population above 30 years in India: A systematic review and meta- analysis. J Glob Health. 2021 Aug 21; 11:04038.
7. Nikolai Khaltaev and Svetlana Axelrod. Chronic respiratory diseases global mortality trends, treatment guidelines, life style modifications, and air pollution: preliminary analysis. Journal of Thoracic Disease. 2019; 11(6).
8. Davies Adeloye, Peige Song, Yajie Zhu, Harry Campbell et al. Global, regional, and national prevalence of, and risk factors for, chronic obstructive pulmonary disease (COPD) in 2019: a systematic review and modelling analysis. 2022;10.
9. MacNee W. Pathogenesis of chronic obstructive pulmonary disease. Proc Am Thorac Soc. 2005;2(4):258-66.

10. Ahmed J.Alfahad, et al Current views in chronic obstructive pulmonary disease pathogenesis and management. Saudi Pharmaceutical Journal. 2021; 29(12): 1361-1373.
11. E. Haydn Walters, et al Fully integrating pathophysiological insights in COPD: an updated working disease model to broaden therapeutic vision. European Respiratory Review. 2021; 30: 200364.
12. MacNee W. Pathology, pathogenesis, and pathophysiology. BMJ. 2006 May 20;332(7551):1202–4.
13. COPD - Symptoms and causes - Mayo Clinic https://www.mayoclinic.org/diseases-conditions/copd/symptoms-causes/syc-20353679
14. Sarkar M, Bhardwaz R, Madabhavi I, Modi M. Physical signs in patients with chronic obstructive pulmonary disease. Lung India. 2019 Jan-Feb;36(1):38-47.
15. Gudagunti AK, Hasabi I, Arathy S. A study of clinical profile of patients with chronic pulmonary obstructive disease at a tertiary care centre in North Karnataka, India. Int J Adv Med 2019;6:455-9.
16. Gupta PP, Govidagoudar et al Clinical and pulmonary functions profiling of patients with chronic obstructive pulmonary disease experiencing frequent acute exacerbations. Lung India. 2018 Jan-Feb;35(1):21-26.
17. Burkhardt R, Pankow W. The diagnosis of chronic obstructive pulmonary disease. DtschArztebl Int. 2014 Dec 5;111(49):834-45.
18. COPD – Diagnosis and Treatment https://www.mayoclinic.org/diseases-conditions/copd/diagnosis treatment/drc-20353685
19. Devine JF. Chronic obstructive pulmonary disease: an overview. Am Health Drug Benefits. 2008 Sep;1(7):34-42.
20. Stages of COPD and the Symptoms https://www.healthline.com/health/copd/what-are-the-4-stages-of-copd
21. Bollmeier SG, Hartmann AP. Management of chronic obstructive pulmonary disease: A review focusing on exacerbations. Am J Health Syst Pharm. 2020 Feb 7;77(4):259-268.
22. Chronic obstructive pulmonary disease (COPD) – Treatment https://www.nhs.uk/conditions/chronic-obstructive-pulmonary-disease copd/treatment/
23. Sawant, Mahadeo et al Study of drug prescription pattern among COPD patients admitted to medicine in- patient department of tertiary care hospital. International Journal of Basic & Clinical Pharmacology. 2017.
24. Krishna, V.N.Vamsi& Ganga M, Siva &Undurthi, Christine. Prescribing Pattern of Drugs in the Management of Chronic Obstructive Pulmonary Disease at an Indian Tertiary Care Teaching Hospital. 2021; 1: 1-3.
25. Salwan, Poonam&Singla, Juhi&Salwan, Shalini. Prescription pattern in the management of chronic obstructive pulmonary disease patients in a tertiary hospital: an observational study. International Journal of Basic & Clinical Pharmacology. 2020.
26. COPD Surgery: Types of Procedures To Consider – WebMD https://www.webmd.com/lung/copd/copd-surgery
27. Surgery for COPD - American Lung Association https://www.lung.org/lung-health-diseases/lung-disease-lookup/copd/treating/surgery
28. Minervini F, Kestenholz PB, Paolini V, Pesci A, Libretti L, Bertolaccini L, Scarci M. Surgical and endoscopic treatment for COPD: patients selection, techniques and results. J Thorac Dis. 2018 Oct;10
29. P. J. Barnes, B. R. Celli. Systemic manifestations and comorbidities of COPD. European Respiratory Journal. 2009;33: 1165-118.
30. McCarthy SD, González HE, Higgins BD. Future Trends in Nebulized Therapies for Pulmonary Disease. J Pers Med. 2020 May 10;10(2):37.
31. Abdellatif S., Trifi A., Daly F., Mahjoub K., Nasri R., Ben Lakhal S. Efficacy and toxicity of aerosolisedcolistin in ventilator-associated pneumonia: A prospective, randomised trial. Ann. Intensive Care. 2016;6:26.

32. Ari, Arzu. Jet, Ultrasonic, and Mesh Nebulizers: An Evaluation of Nebulizers for Better Clinical Outcomes. Euras J Pulm.2014; 16: 1-7.
33. Ibrahim M, Verma R, Garcia-Contreras L. Inhalation drug delivery devices: technology update. Med Devices (Auckl). 2015 Feb 12;8:131-9.
34. Chinese College of Emergency Physicians (CCEP); Emergency Committee of PLA; Beijing Society for Emergency Medicine; Chinese Emergency Medicine. Expert consensus on nebulization therapy in pre-hospital and in-hospital emergency care. Ann Transl Med. 2019 Sep;7(18):487.
35. Ibrahim M, Verma R, Garcia-Contreras L. Inhalation drug delivery devices: technology update. Med Devices (Auckl) 2015;8:131-9.
36. Roth AP, Lange CF, Finlay WH. The effect of breathing pattern on nebulizer drug delivery. J Aerosol Med. 2003 Fall;16(3):325-39.
37. Dhand R., Dolovich M., Chipps B., Myers T.R., Restrepo R., Farrar J.R. The role of nebulized therapy in the management of COPD: Evidence and recommendations. COPD. 2012;9:58–72
38. Hailu N, Postema M, Krejcar O, Assefa D. Nebulization Criteria and Quantification. Fluids. 2020; 5(2):91.
39. Labiris NR, Dolovich MB. Pulmonary drug delivery. Part II: the role of inhalant delivery devices and drug formulations in therapeutic effectiveness of aerosolized medications. Br J Clin Pharmacol. 2003 Dec;56(6):600-12.
40. Longest W, Spence B, Hindle M. Devices for Improved Delivery of Nebulized Pharmaceutical Aerosols to the Lungs. J Aerosol Med Pulm Drug Deliv. 2019 Oct;32(5):317-339.
41. Marques L, Vale N. Salbutamol in the Management of Asthma: A Review. Int J Mol Sci. 2022 Nov 17;23(22):14207.
42. Montuschi P. Pharmacological treatment of chronic obstructive pulmonary disease. Int J Chron Obstruct Pulmon Dis. 2006;1(4):409-23.
43. Button BM, Button B. Structure and function of the mucus clearance system of the lung. Cold Spring HarbPerspect Med. 2013 Aug 1;3(8):a009720.
44. Dhand, R., Dolovich, M., Chipps, B., R. Myers, T., Restrepo, R., & Rosen Farrar, J. (2012). The Role of Nebulized Therapy in the Management of COPD: Evidence and Recommendations. COPD: Journal of Chronic Obstructive Pulmonary Disease, 9(1), 58–72.
45. Jarvis S, Ind PW, Thomas C, Goonesekera S, Haffenden R, Abdolrasouli A, Fiorentino F, Shiner RJ. Microbial contamination of domiciliary nebulisers and clinical implications in chronic obstructive pulmonary disease. BMJ Open Respir Res. 2014 Feb 27;1(1):e000018.
46. Harris JC, Collins MS, Huang PH, Schramm CM, Nero T, Yan J, Murray TS. Bacterial Surface Detachment during Nebulization with Contaminated Reusable Home Nebulizers. MicrobiolSpectr. 2022 Feb 23;10(1):e0253521.
47. Levy ML, Dekhuijzen PN, Barnes PJ, Broeders M, Corrigan CJ, Chawes BL, Corbetta L, Dubus JC, Hausen T, Lavorini F, Roche N, Sanchis J, Usmani OS, Viejo J, Vincken W, Voshaar T, Crompton GK, Pedersen S. Inhaler technique: facts and fantasies. A view from the Aerosol Drug Management Improvement Team (ADMIT). NPJ Prim Care Respir Med. 2016 Apr 21;26:16017. doi: 10.1038/npjpcrm.2016.17. Erratum in: NPJ Prim Care Respir Med. 2016 May 26;26:16028.
48. Sivadasan S, Krishnan A, Dhayalan SV, Aiyalu R. A Systematic Review on KAP of Nebulization Therapy at Home. J Pharm Technol. 2021 Oct;37(5):254-259.
49. Stridsman C, Svensson M, Johansson Strandkvist V, Hedman L, Backman H, Lindberg A. The COPD Assessment Test (CAT) can screen for fatigue among patients with COPD. TherAdvRespir Dis. 2018 Jan-Dec;12:1753466618787380.
50. Marques A, Souto-Miranda S, Machado A, Oliveira A, Jácome C, Cruz J, Enes V, Afreixo V, Martins V, Andrade L, Valente C, Ferreira D, Simão P, Brooks D, Tavares AH. COPD profiles and treatable traits using minimal resources: identification, decision tree and stability over time. Respir Res. 2022 Feb 14;23(1):30.

51. Rajala K, Lehto JT, Sutinen E, Kautiainen H, Myllärniemi M, Saarto T. mMRCdyspnoea scale indicates impaired quality of life and increased pain in patients with idiopathic pulmonary fibrosis. ERJ Open Res. 2017 Dec 14;3(4):00084-2017.
52. Chhabra SK, Gupta AK, Khuma MZ. Evaluation of three scales of dyspnea in chronic obstructive pulmonary disease. Ann Thorac Med. 2009 Jul;4(3):128-32.
53. Janežič A, Locatelli I, Kos M. Criterion validity of 8-item Morisky Medication Adherence Scale in patients with asthma. PLoS One. 2017 Nov 30;12(11):e0187835.
54. Uchmanowicz B, Jankowska EA, Uchmanowicz I, Morisky DE. Self-Reported Medication Adherence Measured With Morisky Medication Adherence Scales and Its Determinants in Hypertensive Patients Aged ≥60 Years: A Systematic Review and Meta-Analysis. Front Pharmacol. 2019 Mar 1;10:168.
55. Tashkin DP. A review of nebulized drug delivery in COPD. Int J Chron Obstruct Pulmon Dis. 2016 Oct 18;11:2585-2596

Access this Article in Online	
Quick Response Code	Website: www.ijcrims.com
	Subject: Clinical Pharmacology
DOI: 10.22192/ijcrms.2025.11.06.004	

How to cite this article:
Tamilselvam K, M. Immanuel Jebastine, K. Karthickeyan, P. Shanmuga Sundaram. (2025). A review on COPD and efficacy and safety challenges of nebulization treatment in COPD management. Int. J. Curr. Res. Med. Sci. 11(6): 40-54.
DOI: http://dx.doi.org/10.22192/ijcrms.2025.11.06.004