OXYGEN AND ASSISTED VENTILATION FOR COPD

INTERNATIONAL COPD COALITION

PHYSICIANS' POCKET GUIDE

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INTERNATIONAL COPD COALITION
Helping the World Breathe Free

International Primary Care Respiratory Group IPCRG

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Aim of this Guide

COPD is the fourth leading cause of death in the world, and its prevalence and health burden will continue to increase. Oxygen and assisted ventilation (or noninvasive ventilation, NIV) are treatments that can improve COPD patients' symptoms, quality of life, activities of daily living, and survival. New studies continue to improve our understanding of the uses of these treatments. This guide, which was written with contributions from expert panel members Antonio Anzueto, Nicholas Hart, Rupert Jones, Sunny Kaul, Yousser Mohammad, and Peter Wijkstra, intends to inform practicing physicians about prescribing oxygen therapy and assisted ventilation, and how they can benefit COPD patients.

COPD Diagnosis, Assessment, and Management

International guidelines [1] describe the airflow limitation that is characteristic of COPD, and recommend that a diagnosis of COPD be considered in any patient over age 40 who has (1) shortness of breath, (2) chronic cough or sputum production, and/or (3) a history of exposure to risk factors for the disease (especially tobacco smoking).

Spirometry, including measurement of FEV_1 and FVC, is key to the diagnosis and severity assessment of COPD. In turn, the severity of COPD determines the treatment plan. A full discussion of COPD management is outside the scope of this document, but is well covered in international guidelines [1].

Oxygen Therapy in Stable COPD

The purpose of long-term oxygen therapy (LTOT) in stable COPD is to increase the patient's blood oxygen level and thereby improve survival and possibly quality of life.

In some patients, LTOT may relieve breathlessness, but this is not its primary goal or effect, and other treatments aimed at decreasing dyspnea (e.g., bronchodilators) should be continued in patients on LTOT. Properly administered, long-term oxygen therapy improves survival in patients who have advanced COPD and chronic hypoxia [2, 3]. This treatment must be used for at least 15 hours per day.

Arterial blood gas testing should be the gold standard to determine which patients should receive LTOT. ***Figure 1*** summarizes a decision-making tree for determining if LTOT is indicated in an individual patient.

The goal of LTOT is to maintain resting PaO_2 > 8.0 kPa (60 mm Hg) and SaO_2 > 90%.

In order to meet this goal, the LTOT prescription needs to include several elements: the duration, source (or sources) of oxygen, method of delivery, and flow rate. There are several variables involved in each of these elements:

Duration: At least 15 hours per day and preferably longer. Most people use oxygen therapy continuously for 8 to 9 hours at night, and additional periods during the day to reach the total of 15 hours. Oxygen therapy administered only at night is not effective [4]. Patients who have decreased oxygen saturation on exertion should be sure to use oxygen when they exercise.

Source: Oxygen can be provided by an oxygen concentrator ***(Figure 2a)***, as compressed gas in a cylinder ***(Figure 2b)***, or as a liquid.

Figure 1. Who Should Receive Long-Term Oxygen Therapy?

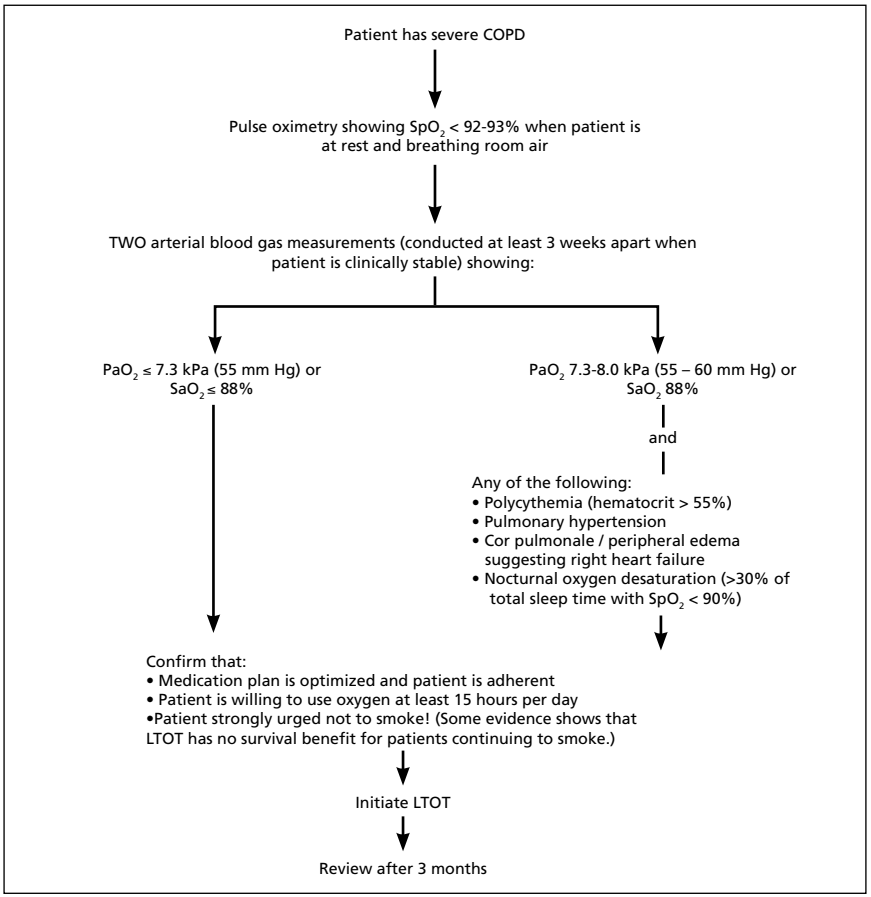

Figure 2. Different Home Oxygen Delivery Systems

a. Stationary oxygen concentrator

b. Oxygen cylinder

Patient mobility is an important issue with oxygen treatment. The patient should have a delivery system that does not impair their ability to exercise, and many patients can be prescribed two different oxygen sources—a stationary unit such as a large gas cylinder or an oxygen concentrator for the home, and a mobile unit (either a portable oxygen concentrator, liquid oxygen container, or small gas cylinder) that permits the patient to exercise and participate in activities outside the home **(Figure 3a-b).**

Figure 3. Portable Oxygen

a. Patient with portable oxygen canister

b. Patients with wheeled cart

Gas Cylinders: Oxygen cylinders are reliable and simple to maintain. Large cylinders that are stationary can be used at home while small portable cylinders (1-2 L) can last about 2-5 hours, depending on the flow rate. When the oxygen in the cylinder is used up, it needs to be refilled by a homecare provider.

Liquid Oxygen: Liquid oxygen can be stored in a large tank for home use and it can be used to fill portable units to provide mobility for about 4-8 hours, depending on the size of the unit and the flow rate. It is reliable and user-friendly. Regular filling (at least 1-2 times per month) by a homecare provider is required.

Oxygen Concentrators: Concentrators provide oxygen from ambient air. Both stationary concentrators and smaller portable concentrators are available. The devices are user-friendly. Electricity is required to power the concentrators; portable units can be powered by batteries, which must then be recharged. With this higher technology, regular maintenance is required.

Method of delivery: Home oxygen is usually prescribed by nasal cannulae ***(Figure 4a)*** but may also be delivered by mask ***(Figure 4b)***. Cannulae do not interfere with eating, drinking, or talking.

Flow rate at rest, during exercise, and during sleep should be prescribed. The flow rate is given in liters per minute (L/min). Because the goal of LTOT is to maintain resting PaO_2 > 8.0 kPa (60 mm Hg) and SaO_2 > 90%, flow rates with different devices should be individually titrated by oximetry and/or arterial blood gas measurement to correct hypoxia without significantly increasing carbon dioxide in the blood.

Oxygen requirements generally increase during exercise. Some experts recommend increasing the flow rate to the mask or nasal cannulae by about 1 L/min during exercise and sleep in order to maintain oxygen saturation.

Other Situations

There is no evidence for prescribing LTOT to COPD patients who are breathless during exercise but do not fulfill the criteria for LTOT [5]. However, there are two other

circumstances in which oxygen therapy is prescribed: (1) during and after COPD exacerbations (see below), and (2) ambulatory oxygen therapy.

Ambulatory oxygen therapy (AOT) is usually reserved for patients on LTOT, but may be beneficial for some patients with exercise desaturation and breathlessness that restrict their activities. The assessment of these patients involves a standardized test such as the six-minute walking test or the incremental shuttle walking test while monitoring pulse oximetry. AOT is considered for people who desaturate by more than 4% and to below 90%. Initially the test is performed breathing air, then repeated after 30 minutes' rest when the patient is using the ambulatory oxygen. AOT is indicated if the patient shows (i) improved walking distance, (ii) improved breathlessness, and (iii) wishes to use the equipment. [6]

Figure 4. Methods of Oxygen Delivery

a. Patient using nasal cannulae

b. Patient using face mask over nose and mouth

Oxygen Use in Air Travel

Although air travel is safe for most COPD patients with chronic respiratory failure who are on LTOT, patients should be instructed to discuss upcoming travel with their physician 15 to 30 days ahead of time. The physician should be prepared to provide a certificate or letter indicating the patient's fitness to fly which can be provided to the airline. Patients should be made aware that they can contact the airline to arrange for oxygen gas cylinders, or contact their home health care provider to obtain a portable oxygen concentrator for the flight.

A general rule of thumb for air travel is to increase the flow by 1-2 L/min during the flight. Ideally, patients who fly should be able to maintain an in-flight PaO_2 of at least 6.7 kPa (50 mm Hg). Studies indicate that this can be achieved in those with moderate to severe hypoxemia by supplementary oxygen at 3 L/min by nasal cannulae. Those with a resting PaO_2 of > 9.3 kPa (70 mm Hg) are likely to be safe to fly without supplementary oxygen. However, co-morbidities such as cardiac impairment or anemia may impair oxygen delivery to tissues and make air travel unsafe.

Since the oxygen concentration in air decreases with increasing altitude, patients with advanced COPD must also be advised to use caution in visiting places in the mountains or at high altitude.

Hazards and Toxicity of Oxygen Therapy

The risk of house fires is increased as the oxygen level rises; in particular, smoking and open fires represent hazards. When patients are on LTOT at home, they may trip and fall over oxygen tubing and power cords. In some patients, oxygen therapy reduces hypoxic respiratory drive and results in hypoventilation and thus hypercapnea. Patients with COPD, especially during exacerbations, may retain CO_2 and have symptoms of drowsiness, confusion, and headache with a bounding pulse, tremor, and reduced level of consciousness. Sudden cessation of oxygen therapy may cause life-threatening rebound hypoxia.

What is Noninvasive Ventilation?

Noninvasive ventilation (NIV, also called face-mask or assisted ventilation) is a treatment for acute respiratory failure that involves provision of ventilator support through the patient's upper airway using a mask ***(Figure 5)***. The primary goal of NIV is to improve gas exchange by increasing ventilation. It is primarily used in patients with hypercapnic (type 2) respiratory failure. Positive-pressure devices for NIV are now commonly used to treat exacerbations of COPD with acute acidotic hypercapnia. Research is underway to examine the use of NIV following hospital discharge after a COPD exacerbation, in pulmonary rehabilitation, and in other clinical situations.

Figure 5. Patients Receiving Noninvasive Ventilation

NIV in COPD Exacerbations

When added to standard therapy for a COPD exacerbation, NIV reduces the need for intubation [7], improves survival [7], and lowers costs [8]. Strong evidence supports the use of NIV in patients with acute respiratory failure and decompensated respiratory acidosis (pH < 7.35 and $PaCO_2$ > 6 kPa) during a COPD exacerbation. NIV should be considered within the first hour following hospital admission for COPD exacerbation in all patients in whom respiratory acidosis persists despite standard medical treatment, which includes a regimen such as the following:

Controlled oxygen to maintain SaO_2 88-92%
Nebulized salbutamol 2.5-5 mg q 4-6 hours
Nebulized ipratropium 500 µg q 6 hours
Prednisolone 30 mg once daily
Antibiotic when indicated

The initiation of NIV should only be performed by a health care professional trained in its proper use. Recommended initial settings [10] are an inspiratory positive airway pressure (IPAP) of 10 cm H_2O and an expiratory positive airway pressure (EPAP) of 4 cm H_2O. These initial settings are well tolerated by a wide range of patients to allow acclimatization to the machine. In addition, setting the EPAP at 4 cm H_2O reduces CO_2 rebreathing and assists triggering of the ventilator.

Subsequently, the IPAP can be increased by 1-2 cm increments at a rate of approximately 5 cm H_2O each 10 minutes, with a pressure target of 20 cm H_2O or until a therapeutic response is achieved or patient tolerance has been reached.

To initiate NIV, the patient should be in a sitting or semi-recumbent position. A full-face mask should be used for the first 24 hours, after which a nasal mask may be used if preferred by the patient. An assessment of mask fit, skin condition, and degree of leak should be done. Patient comfort and synchronization with the ventilator are key factors in achieving a successful outcome.

Oxygen, when required, should be entrained into the circuit and the flow adjusted to achieve target saturation of > 90% [10]. Bronchodilators should be administered off NIV when possible, but may be administered while the patient is on NIV by entraining between the expiration port and facemask. Delivery of both oxygen and nebulized solutions is affected by NIV pressure settings.

An improvement of pH and a reduction in respiratory rate after 1 hour of NIV is associated with a successful outcome. In addition, arterial blood gas measurement should be performed after 1 hour of NIV therapy and 1 hour after every subsequent change in settings. Then, arterial blood gases should be measured after 4 hours (or sooner in patients who are not improving clinically).

Frequent monitoring of acutely ill patients is recommended: every 15 minutes for the first hour, every 30 minutes during hours 1-4, and hourly during hours 4-12.

Recommended clinical observations include:
- Respiratory rate
- Heart rate
- Level of consciousness
- Patient comfort
- Chest wall movement
- Ventilator synchrony
- Accessory muscle use

Most patients treated with NIV for acute respiratory failure can be weaned from ventilator support within a few days. If NIV is required beyond this period it may be an indication that longer term NIV may be indicated.
Before discharge from the hospital, a patient who has been weaned from NIV should undergo arterial blood gas testing while breathing air. If hypoxemia is present (PaO_2 < 8.0 kPa or SaO_2 < 90% without supplemental oxygen) then the patient needs oxygen therapy for home use. If LTOT is initiated, another arterial blood gas measurement (while the patient is breathing air) should be taken 3 months later to determine if oxygen treatment needs to be maintained; about one-third of patients will no longer need it.

Recommendations After Discharge From Exacerbation

At discharge, maintenance medication must be reviewed as previous regiments might be suboptimal and compliance insufficient.

Opportunities for prevention of future exacerbations should be reviewed before discharge, with particular attention to smoking cessation, current vaccination status (influenza and pneumococcal vaccines), knowledge of current therapy including inhaler techniques, and how to recognize symptoms of exacerbations. Pharmacotherapy known to reduce the number of exacerbations such as long-acting inhaled bronchodilators, inhaled glucocorticosteroids, and combination inhalers should be considered. Early outpatient pulmonary rehabilitation after hospitalization for a COPD exacerbation is safe and results in clinically significant improvements in exercise capacity and health status at 3 months. Social problems should be discussed and principal caregivers identified if the patient has a persistent disability.

NIV in Other Situations/Long-Term NIV

The ability to support patients with chronic respiratory failure in the home has been a major advance in respiratory medicine, and the feasibility of providing NIV via facemasks or nasal facemasks may also provide benefits. However, the clinical outcomes of home mechanical ventilation for different diagnostic groups are not yet clear. At present, in some European countries (though less often in North America), long-term NIV is provided to COPD patients who have recurrent admissions for severe COPD exacerbations requiring NIV, with the aim of reducing hospital readmission rates. This clinical approach is currently the focus of two large clinical trials in Europe.

While preliminary studies suggest that combining NIV with long-term oxygen therapy could improve some outcomes, there is no evidence to routinely prescribe this treatment. Compared with long-term oxygen therapy alone, there is some evidence that the addition of NIV can improve shortness of breath [12] in some patients, lessen carbon dioxide retention [13], and may improve short-term survival [13]. Sometimes NIV is prescribed for patients who are being discharged from the hospital after an exacerbation but remain hypercapnic. An uncontrolled study found that chronic NIV decreased the number of admissions and lowered costs [14]. It is hoped that randomized controlled trials of NIV in these situations that are currently underway will provide the necessary guidance on these points.

Studies are also examining the combination of NIV and pulmonary rehabilitation. When patients in pulmonary rehabilitation also receive NIV during the night, they show more benefit than patients who do not receive NIV [15].

Randomized controlled trials are also currently underway in the UK and Netherlands to evaluate the use of chronic NIV after acute respiratory failure, and to evaluate whether or not the quality of sleep can be improved with nocturnal NIV, what the minimum number of hours of NIV usage during the night would be for it to be effective, and whether it would be more or less effective than NIV during the day.

Perspective in Developing Countries

In many developing countries, oxygen therapy and the technology to support it is not widely available. Primary care doctors frequently lack access to oximeters, and arterial blood gas measurements can only be carried out at central referral hospitals. Oxygen concentrators are replacing cylinders for oxygen therapy, but disruptions in electricity and lack of resources for maintenance remain serious limitations. Another urgent need is for the development of easy-to-use ventilators designed to be reliable for use in the most deprived areas of the world. As is the case elsewhere, training of health care professionals in the use of both long-term and acute oxygen therapy is required [16].

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