DOI: 10.7860/JCDR/2023/59430.17342

Review Article

Internal Medicine Section

Oxygen Therapy and Associated Risk Factors for Home Isolated COVID-19 Patients: A Review

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ABSTRACT

During the second wave of the viral pandemic, hospitals were overcrowded by the escalation of Coronavirus Disease-2019 (COVID-19) cases. To effectively address the drastic escalation of the COVID-19 pandemic, innovative solutions are warranted. The rising demand for critical-care services burdens hospitals; hence, to alleviate the burden on the healthcare system, asymptomatic patients or those with mild symptoms can be treated at home through continuous monitoring and care. Affected patients are at risk of hypoxia, which urgently requires oxygen therapy. Depending on the extent of oxygen demand, patients can boost their oxygen levels by making use of a nasal cannula, face mask, oxygen cylinder, and/or oxygen concentrator. Several risk factors are associated with the augmented probability of COVID-19 progression to severe status due to increased oxygen requirement, and they include advanced age, obesity, glucose intolerance, hypertension, and cardiovascular disease. A close monitoring of oxygen saturation (SpO_2) along with other clinical investigations like complete and differential blood counts, serum electrolytes, random blood sugar, liver function tests, coagulation profile (Prothrombin Time (PT), activated Partial Thromboplastin Time (aPTT) and International Normalised Ratio (INR)), renal function test, C-reactive protein (CRP), D-dimer and ferritin level are mandatory for patients receiving home-based oxygen therapy. An awareness of safety considerations such as perfectly fitting, proper sized mask, availability of ventilation, knowledge of caregiver about danger signs and good functioning of fire alarm system at home are of prime importance before setting up oxygenation devices at home, and this further mandates a comprehensive evaluation of home-based management and treatment of mildly symptomatic patients with COVID-19.

Keywords: Coronavirus disease-2019, Home remedy, Oxygen devices, Safety measures

INTRODUCTION

Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) is deadly zoonotic virus which multiply profusely. During the second wave of this viral pandemic, hospitals were overcrowded [1,2]. Moreover, due to an increased demand for critical-care services, the pressure on Intensive Care Unit (ICU) bed facilities, mechanical ventilators, personal protective equipment, and healthcare personnel poses a threat to the excellence and safety of healthcare management [1,2]. Nonetheless, self-care under home quarantine is recommended for asymptomatic and mildly symptomatic patients. Patients with COVID-19 exhibit a broad spectrum of symptoms that affect multiple systems, among which the respiratory system is the most commonly affected, and home-based management of patients with respiratory disorders is challenging; hence, different strategies need to be formulated for the treatment of these patients [3]. A proportion of mild COVID-19 patients recover with medication while in home isolation; however, a subset requires supportive therapy, such as subcutaneous heparin and oxygen supply management in the home-based-care setting [4]. These provisions potentially mitigate the necessity of hospital admission. Oxygen supplementation can be provided at home, though it requires proper monitoring.

Therefore, this review summarises the mechanisms and side-effects of commonly used oxygen-therapy measures or techniques for patients with COVID-19, thus availing comprehensive information that may help maximise oxygen-therapy benefits, minimise risk, and hopefully, reduce mortality in patients with COVID-19.

Cause of Oxygen Requirement at Home during the COVID-19 Pandemic

Stable patients with SpO_2 of 92% at rest should be referred for oxygen therapy. Due to the incapacitation of local healthcare systems, particularly the limited availability of hospital beds during the peak of pandemic situation [5,6]. Patients with mild symptoms opt to stay at home with home-based care provided by government [7]. Rapid clinical deterioration signs like dyspnoea (shortness of breath) and/or cyanosis, (when the body is deprived of adequate oxygen supply at the tissue level); fever, cough, including low SpO_2 (<92%) etc., may arise in the preliminary phase of the disease due to the development of silent and unpredictable arterial hypoxaemia, even without an associated increase in exertion related to breathing [8].

Home-based Monitoring of Oxygen Status

Telemedicine has played an important role in providing guidance to patients as well as caregivers who can understand advice given by a physician over the phone. Their temperature, SpO_2, and pulse measurements are monitored daily at home. The clinical progression of COVID-19 is unpredictable; hence, one should be cautious to monitor and document the patient's signs and symptoms to identify initial signs of deterioration that potentially occur to an inconsequential extent in patients opting for home isolation, as mild symptoms may not require hospital admission at an early stage [9-11]. After testing positive with the Reverse Transcriptase Polymerase Chain Reaction (RT-PCR) test, continuous self-monitoring of SpO_2, heart rate beats per minute (bpm), and body temperature at home is mandatory. Certain tests, such as 6-minute walk tests, can indicate the need for oxygen therapy in patients receiving home isolation whose SpO_2 levels are within normal limits (i.e., SpO_2 levels of 92% or higher at rest under normal room air conditions) [12-15]. It is recommended that such patients walk across the room for approximately six minutes at a normal pace and remeasure their oxygen level. A decline in oxygen level after the walk indicates early hypoxia and the requirement for oxygen. The minimum normal SpO_2 level is reportedly 92% [12,13], while other studies have reported this value to be between 93% and 94% [15,16]. The pulse oximeter is a potentially useful device for measuring patient SpO_2 (where 'p' refers

to a pulse-oximetry measurement) and bpm levels. It has a finger disposable wireless sensor enabling continuous SpO_2 monitoring. The user-friendliness and affordable cost of pulse oximetry renders it a preferable alternative for detecting problems at an early stage; however, one should be wary of its accuracy, particularly when SpO_2 levels fall below 90%. When monitoring the SpO_2 level at home using a pulse oximeter, individuals should take several precautionary measures [17]:

i) Before taking a measurement, the patient must be relaxed and breathing calmly without talking for some time.

ii) Measurements should be taken indoors, with the device placed firmly on either the middle or ring finger.

iii) Nail paint (if any) should be removed.

iv) Cold extremities must be warmed prior to monitoring.

v) The person should patiently observe the readings for 30-60 seconds to identify the most precise value associated with a strong pulse signal.

vi) The SpO_2 level should be measured several times a day to precisely estimate the trend in arterial oxygenation.

vii) Individuals should take care of themselves and make appropriate decisions promptly if their SpO_2 level exhibits a declining trend over a time.

Oxygen monitoring can also be performed using spirometry. Conventional spirometry measures lung function that can be performed during normal tidal breathing. With this technique, one must breathe into a device that reflects how effectively their lungs are working [18].

Oxygen Sources that can be made Available at Home

SARS-CoV-2 causes severe injury to the lungs, thus adversely affecting respiratory function. The alveolar-capillary membrane that exchanges oxygen and carbon dioxide is affected, thus causing oxygen deficiency, which must be remedied by external oxygen-administration devices. Low tissue oxygenation/hypoxia potentially occurs due to system failure in terms of oxygen transport and circulation. Hypoxia indicates the need to initiate oxygen therapy, which is a potentially life-saving intervention; nevertheless, it should be administered upon proper evaluation and constant assessment; otherwise, it is potentially disadvantageous to the patient's health [19]. Several oxygen sources can easily be made available at home. The selection of oxygen-delivery devices depends on the extent of oxygen requirement, degree of patient acceptance, device efficiency and consistency, and ease of therapeutic application. The clinical evaluation, performance, and design of the device ultimately determine which oxygen-delivery device and mode of administration should be preferred [20,21]. The percentage of oxygen delivered can be inconsistent or precise, depending on the device and mode of administration selected. Oxygen can be delivered via low- or high-flow systems, with or without humidity, and with or without a reservoir. The monitoring of oxygen-delivery effectiveness entails arterial blood-gas analyses, SpO_2 monitoring, and clinical assessment [21].

Delivery Devices

Although oxygen therapy cannot instantaneously boost oxygen levels or restore them to normal in patients with COVID-19. The primary form of treatment in moderate cases is oxygen therapy: the goal is to achieve 92-96% SpO_2 or 88-92% in patients with Chronic Obstructive Pulmonary Disease (COPD) by following means [22,23]:

Nasal cannula: Nasal cannulas are the most common devices for oxygen delivery. The device comprises a low-flow system, with flow rate ranging from 1-6 L/min. It supplies 24-44% inspired oxygen at a rate exceeding 4 L/min. It consists of a flexible tube that is placed under the nose. The tube includes two prongs that enter the nostrils. Oxygen transported to the nasopharynx via a nasal cannula combines with room air; therefore, oxygen concentration in the nasal cannula varies depending on the patient's respiratory rate, tidal volume, oxygen flow rate, and degree of mouth breathing [14]. Hence, nasal cannulas are suitable for patients with COVID-19 experiencing low respiratory distress primarily because they are less intrusive than other devices and allow a person to eat and speak freely.

Disadvantages

a) The nasal cannula potentially causes discomfort due to mucous-membrane dryness.

b) It can also cause nasal bleeding due to continuous irritation and breach of tissue [22].

Face masks: Simple face mask- The simple, or 'low-flow', face mask is used when an increased delivery of oxygen is required for short periods (i.e., <12 hours). Oxygen is delivered at a flow rate of 2-10 L/min and is transported at a concentration of 35-60%. The device covers the nose and mouth and has vents on its sides that allow room air to enter via several entry points, thereby diluting the source oxygen and supplementing it with air drawn into the mask during breathing. The SpO_2 achieved cannot be predicted as it depends on the rate and depth of the patient's breathing [22,24].

Disadvantages

a) The simple face mask, including the accompanying nasal tube, is expensive.

b) A face mask is uncomfortable for patients while eating or talking.

c) Inflammation of skin due to continuous use is likely to occur.

d) It is difficult to position over the nose and mouth.

e) To deliver a high concentration of oxygen, a tight seal is necessary.

Non rebreathing face mask: The non rebreathing face mask is indicated for acute oxygen-desaturation conditions. It provides the highest concentration of oxygen (upto 90%) at a flow rate of 10-15 L/min via a reservoir mask and is recommended for short-term use in patients who are critically ill. The reservoir bag must be filled with oxygen before use and the mask well positioned to ensure a close fit on the patient's face. Two one-way valves prevent exhaled air from entering the bag. When the patient exhales, the one-way valve closes and all the expired air is deposited into the atmosphere, not the reservoir bag. Therefore, the patient does not rebreathe any of the exhaled gas [24]. Oxygen via a reservoir mask cannot be humidified, and patients tend to be more comfortable if their oxygen levels can be maintained within target range on a humidified system once they are more stable. This mask is appropriate for patients with COVID-19 who are breathing spontaneously and severely hypoxaemic, as it delivers the highest possible oxygen concentration.

Disadvantages

a) Its major drawback is that the mask must be tightly sealed on the face, which is uncomfortable and has a drying effect.

b) It is considerably expensive.

c) Malfunction can be a source CO_2 accumulation.

d) It is impractical in cases of long-term oxygen therapy [22].

Venturi/Air entrainment mask: This is a high-flow device that delivers a fixed oxygen concentration of 24-54%. It utilises a flow metre to provide a constant, precise, and preset oxygen level. It of a sterile water bottle, ridged tubing, drainage bag, air/oxygen ratio nebulising system, and masks that work with corrugated tubing. The mask maybe an aerosol face mask, tracheotomy mask, T-piece, or face tent. The key is that oxygen flow exceeds the patient's peak inspiratory flow rate, with a slight chance of the patient inhaling air from the room. The device is commonly used to control a person's carbon dioxide retention and supply supplemental oxygen. Hence, this device is apt for patients with COVID-19 who have a hypoxic drive to breathe but also require supplemental oxygen. It delivers

humidified oxygen without drying mucous membranes, hence proving comfortable for patients [22].

Disadvantages

a) The mask potentially causes discomfort as it can be hot and confining for patients and also cause interference while talking and eating.

b) A properly fitting mask is required.

c) In added instances, respiratory therapists/nurses may be accountable for regulating and monitoring the high-flow systems.

Oxygen cylinders: An oxygen cylinder is a storage container made with reinforced metal. It is filled with compressed oxygen under high pressure, which is safely and gradually released via its regulator tap, and the oxygen is supplied to the patient through a surgical mask via nasal cannula. The water flask or humidifier that accompanies the cylinder must be filled with normal tap water up to the marked level. Oxygen is moistened as it passes through it to prevent the mucous membranes of the respiratory tree from drying, and the humidifier is connected to a flow metre that regulates oxygen flow in L/min. A reduction gauge displays the residual amount of oxygen in the tank. Setting up an oxygen cylinder requires technical assistance, which can be sought from the service provider [22]. To distinguish them from devices carrying other medical gases, oxygen cylinders are colour coded with a white exterior. The cylinders come in various capacities, and the appropriate cylinder must be selected, depending on the patient's oxygen requirement; moreover, when the cylinder's supply is exhausted, it should be refilled before use. A larger, freestanding cylinder can be used in the home as a back-up source in the event of power failure. A portable cylinder is designed to use even outside and it can be attached to a walker, wheelchair, or can be carried in a backpack [25].

Disadvantages

a) Proper attention is required when checking the cylinder's oxygen level.

b) Awareness of duration is required [25].

Oxygen concentrators: Oxygen concentrators, also referred to as oxygen generators, are electrically powered devices that purify ambient air and redirect nitrogen back into the air, thus providing filtered oxygen to the patient through a cannula. Atmospheric air contains 21% oxygen, 78% nitrogen, and 1% other gases. The purified air supplied to the patient is approximately 90-95% pure. By means of a pressure valve, oxygen supply can be adjusted to flow rates ranging from 1-10 L/min. In the context of COVID-19, the use of transportable/portable oxygen concentrators at flow rates ≤4 L/min is recommended [15]. The supply should be set according to the patient's clinical requirement. Unlike oxygen cylinders, concentrator's require uninterrupted power supply for their operation. Even a brief power cut could adversely affect the patient. Concentrators can be either stationary at home or portable with the patient [26-28]. A portable oxygen concentrator includes its own power supply; furthermore, it is a compact, lightweight machine that is designed formability and can be carried around outside the home [29-31]. Home concentrators require installation and regular maintenance by specialised expertise. In the context of the COVID-19 pandemic, this is not ideal since it potentially increases exposure risk of infection.

Disadvantages [20,32]

a) Concentrators require a continuous supply of electrical power to function; this may entail the setting up of a backup power generator in the home.

b) Patients should change the filters weekly, and timely service of stationary oxygen concentrators is required.

Natural boosting: Several exercises, yoga, and other similar activities can be used to boost oxygen levels naturally at home, apart from oxygen-supply devices and resources. During hypoxia, patients with COVID-19 are advised to sleep in the prone position, in which they lie on their chest with pillows placed under their neck, shins, and chest. Patients can also lie on their sides. In addition, having a nutritious, iron-rich diet that improves lung function is said to be beneficial. According to doctors, lying on one's tummy when suffering from a respiratory infection like this is potentially advantageous. Some patients have been reported to recover or exhibit improvements in their health by prone positioning alone [33].

Assessment of Risk Factors Associated with Home-based Oxygen Therapy

During the COVID-19 pandemic, several clinical factors and laboratory findings have been reported to be associated with disease progression, ultimately leading to severe illness or mortality. Major factors include advanced age, obesity, glucose intolerance, hypertension, and cardiovascular disease. These constitute independent host risk factors for oxygen requirement in patients with COVID-19.

Advanced age: As confirmed by several studies, advanced age emerges as one of the risk factors for oxygen requirement in patients with COVID-19 globally [34,35]. This is potentially attributable to a less rigorous immune response in advanced age [35]. Notwithstanding to date, the reason underlying old age-related susceptibility remains unclear.

Obesity: Obesity is another risk factor reportedly associated with the augmented probability of COVID-19 progression toward severity [36]. Disease progression is reportedly seven times higher in patients with obesity [37]. Patients with obesity and concomitant lung diseases (asthma and COPD) may experience an excessively high percentage of total body oxygen consumption as well as a decline in functional residual capability and expiratory volume [18]. Additionally, people with obesity are at a higher risk of developing pulmonary emboli/aspiration pneumonia [38], and these secondary pathophysiologies may exacerbate pneumonia in patients with COVID-19, resulting in progression to severe infirmity. However, the precise mechanisms underlying the association between obesity and COVID-19 progression remains unclear. Promoting a healthy diet to sustain nutritional requirements has become increasingly essential in the battle against COVID-19.

Glucose intolerance: Diabetes mellitus, the most common metabolic disease worldwide, weakens the immune system [39] and is reportedly another risk factor for disease severity or mortality in COVID-19 [40,41]. Hyperglycaemia, even in patients with undiagnosed diabetes, has also been reported to be a predictor of poor clinical outcome and mortality [42]. People with diabetes mellitus have been reported to be three times more likely to progress to severe disease or death from COVID-19 [43], and this trend is likely to be worse in patients with uncontrolled diabetes [44]. Hyperglycaemias were seen in non diabetic patients because of steroid use and catecholamine surge due to stress [45]. A study observed hypoglycaemia in COVID-19 patients related to decrease oral intake or in sepsis [46].

Hypertension: Hypertension is known to be a genetic condition that is worsened by external factors, such as lifestyle, stress, and diet. With the progression of age, blood pressure rises due to a disorder in the blood vessels, such as atherosclerosis, thus affecting lung function and impairing oxygen delivery; moreover, it is a potential cause of high mortality among patients with COVID-19 [34,40,47].

Cardiovascular disease: Patients with co-morbid cardiovascular disease are more susceptible to COVID-19 [34,41,47]. The reason behind this phenomenon maybe associated with angiotensin-converting enzyme 2 (ACE2) expression in vascular fibroblasts and myocytes [48]. The presence of SARS-CoV-2 in cardiovascular cells potentially aggravates the disease. Body mass index, low lymphocyte count, glucose intolerance, and dyslipidaemia are reportedly significant risk factors for oxygen requirement [49].

Safety Considerations before Setting up a Home-based Oxygen-delivery System

Despites its benefits, several safety considerations should be followed before setting up an oxygenation device at home [22]:

a) A perfectly fitting, proper-sized oxygen mask, including an accompanying nose clip and tightened strap, should be used to avoid leakages or gaps in/and around the nose and minimise oxygen-supply interruptions.

b) Due to an inadequate resource supply, many cannulas and concentrator machines are borrowed/shared among users; therefore, caregivers and patients with COVID-19 should ensure that equipment, devices, cannulas, and masks are well sanitised before use.

c) Sufficient ventilation and open windows must be available in the room while using an oxygen concentrator, as this will allow eliminated nitrogen to escape freely.

d) Caregivers should be aware of the dangers of using home oxygen in the presence of a naked flame, such as that from cookers and candles. Oxygen cylinders could cause an explosion; hence, they should be ≥5 feet away from naked flames, a heat source, or electrical devices. Smoking cessation must be advocated.

e) Fire alarms and smoke detectors should ideally be installed in the home and consistently being in good working order.

f) Documented training should be availed to patients/caregivers before ordering home oxygen [35].

g) Oxygen supply should be immediately turned off when not in use, and the nasal prongs or mask should never be left under or on bed coverings or cushions whilst oxygen is being supplied.

i) Aerosol sprays and petroleum products/by-products (e.g., petroleum jelly/Vaseline) must not be used whilst using oxygen.

j) Oxygen cylinders must be secured to prevent them from falling over and stored upright, either chained or secured in appropriate holders.

CONCLUSION(S)

The appropriate selection of home-based oxygen-therapy devices and delivery systems for patients with COVID-19 depends on the extent of hypoxaemia, existing indication for the patient's fundamental diagnosis, and predilection. Caregivers should possess a consolidated knowledge of all devices and delivery systems for them to devise appropriate and individualised patient-based plans for home-based oxygen therapy. An awareness of potential harm and safety considerations is of paramount importance, and this further mandates a comprehensive evaluation of home management and treatment of COVID-19 patient with mild symptoms.

Acknowledgement

Authors would like to express their heartfelt gratitude to all of the co-authors for their invaluable contributions and assistance in bringing this article to fruition.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Aug 03, 2022
- Manual Googling: Nov 05, 2022
- iThenticate Software: Nov 07, 2022 (20%)

ETYMOLOGY: Author Origin

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was informed consent obtained from the subjects involved in the study? NA
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Aug 01, 2022**
Date of Peer Review: **Sep 19, 2022**
Date of Acceptance: **Nov 08, 2022**
Date of Publishing: **Jan 01, 2023**