

ARE OXYGEN GAS CYLINDERS SAFE FOR HOME MEDICAL USAGE?

SRINIVAS BIKKINA¹, VIJAYA KITTU MANDA², U. V. ADINARAYANA RAO³
S. S. PRASADA RAO⁴

^{1,2} Research Scholar, GIM, GITAM Deemed to be University, Visakhapatnam

^{3,4} Professors, GIM, GITAM Deemed to be University, Visakhapatnam

ABSTRACT: COVID-19 pandemic created artificial demand for oxygen gas cylinders for medical use - both at hospitals and curiously, for home use by patients. Some patients and even healthy individuals explore the possibilities and potential advantages of using oxygen from cylinders for residential usage. However, this is not always safe, and adequate precautions are to be taken, failing which there can be fatalities. This paper explores the importance of maintaining adequate levels of oxygen levels suitable for human consumption. It appraises the medical use and the pros and cons of storing oxygen cylinders at residence. The study also touches upon legal and regulatory aspects. The study's findings can help individuals make an informed decision on the safe use of oxygen gas. Further, it alerts on the increased importance of regulations and restricting access and use.

KEYWORDS: Oxygen gas, home oxygen, medical oxygen, oxygen cylinder, oxygen therapy

INTRODUCTION

Oxygen is an invincible and inevitable gas used in diversified industrial applications such as welding, cutting, brazing, and other metal fabrication activities, and in medical and healthcare applications. Oxygen gas is compressed and filled in a high-pressure cylinder to make it easy to transport. The medical use and benefits that accrue from the usage of oxygen are innumerable. However, it requires safe handling by qualified and trained personnel failing which the lives of various stakeholders, including that of the patient's health condition could be in danger. Overdosage, or over-usage of oxygen, can put the patient into a coma while insufficient levels could lead to breathlessness. Several researchers questioned the benefits that accrue from the clinical settings at which medical oxygen is routinely used. [1] The care and caution of dealing with oxygen begin from the stage of filling it to the cylinders, and later through the transportation till the final step of fixing of equipment and end-patient delivery. Failures in safe handling can lead to an accidental blast that can claim human lives. [2]

OBJECTIVES OF THE STUDY

1. To understand the importance of oxygen as a medical gas.
2. To appreciate why under-supply or excess-supply of oxygen is hazardous
3. To understand the dangers involved in using oxygen cylinders at home

REVIEW OF LITERATURE

Long-term oxygen therapy (LTOT) is strongly suggested for chronic obstructive pulmonary disease (COPD) and other severe hypoxemic lung diseases such as hypoxic chronic pulmonary disease. Portable Oxygen Concentrators (POC) are the devices used in most cases.

Researchers suggested several ways of effectively using medical oxygen. For instance,[3] suggests first an initial prescription for 15 h or more per day followed by a supplementary education on oxygen therapy by a nurse or physiotherapist, requirement of cessation of smoking and the use of oxygen in all domestic situations (toilet, meals, and leisure), and to measure and find the absence of side effects from oxygen treatment. For example, severe burns are reported because of smoking while connecting oxygen delivery equipment. [4] Several hazards such as tobacco smoking, cooking, candles, household heating, outdoor, flammable materials, sparks, and others could lead to risk. [5] Equipment manufacturers, oxygen gas cylinder providers, and the fire safety department often provide leaflets and manuals that speak in length about care to be taken with oxygen to prevent hazards. The various steps include doing a risk assessment before installation, about oxygen enrichment, care not to use materials that are incompatible with oxygen, not to use oxygen in equipment that is not explicitly designed for the purpose, and other precautions.[6]

Medical oxygen gas being a drug, requires a prescription for home use, mainly when it is to be used for more prolonged usage. For patients to whom it is prescribed, it is usually far more than optional. Despite this, advice, counseling, and education on its correct usage are hardly provided. [7] Another study found that patients on LTOT tended to overestimate their oxygen usage, and acceptable compliance was observed in 65 percent of the patients. [8] Research suggests that respiratory therapists (RTs) have to consistently evaluate patients hospitalized for COPD exacerbations for home oxygen before discharge and that only a minority are involved in selecting home oxygen equipment. [9] Even more than the patient, physicians should know the features of new and technologically updated home oxygen therapy (HOT) devices. [10]

While there is ample literature on the topic of oxygen cylinders, this paper adds to our body on knowledge on the understanding of the usage of cylinders at home, mainly when increased enthusiasm is seen for their usage at home amidst COVID-19 pandemic.

OXYGEN LEVELS IN BLOOD

Before a patient is administered oxygen, the existing levels of the arterial blood are first determined. A pulse oximeter is typically used for this. Individuals can buy a pulse oximeter from a local medical device store or online store. In the operating room, superior quality pulse oximeters are used as part of anesthesia procedures by anesthetists. [11] The oximeter can be clipped to a finger and hence quite simple to use and does not involve collecting blood samples. Hence, it is quick and decently accurate. The oxygen levels in the blood will usually be between 95 and 100 percent. Oxygen saturation levels below 90 percent can lead the patient to a condition called Hypoxemia. This results rapidly in forcing the patient to breathe more profoundly, have a higher heart rate, shortness of breath, coughing, wheezing, sweating, changes skin-color, confusion amongst others. This condition requires the patient to seek immediate medical assistance.

OXYGEN CONCENTRATION LEVELS & SIDE EFFECTS

Oxygen is essential for breathing, but the required concentration level of oxygen in ambient air is a mere 19.5 percent. [12] Naturally, breathable air at sea level contains oxygen that is generally sufficient for the humans. However, the oxygen levels in the air can drop if toxic gases in the air increase. Occupational Safety and Health Administration (OSHA) states the oxygen levels for humans to breathe to be between 19.5 and 23.5 percent. Table 1 shows the side effects when the oxygen level is lower (such as loss of mental functions) or if the levels go higher (muscle twitching, tissue, or cell damage) than the desired levels.

Table 1: Side effects of oxygen deficiency exposure

Oxygen concentration (% vol)	Effect of the health of a person while resting
19	Some adverse physiological effects occur, but they may not be noticeable.
15-19	They have impaired thinking and attention, increased pulse, and breathing rate. Reduced coordination and decreased the ability to work strenuously. It reduced physical and intellectual performance without awareness.
12-15	Poor judgment. Faulty coordination. Abnormal fatigue upon exertion. Emotional upset.
10-12	Abysmal judgment and coordination, Impaired respiration that can cause permanent heart damage. Possibility of fainting within a few minutes without warning. Nausea and vomiting.
Less than 10	Inability to move and to faint almost immediately. Loss of consciousness. Convulsions. Death.

Source: AirProducts[13]

EXCESS DELIVERY OF OXYGEN TO PATIENT

Oxygen is a drug. This statement, however, appears strange because oxygen is commonly available in the atmosphere on Earth all the time. So trivial is that we keep breathing it all the time. However, the amount of oxygen we breathe in through room air is a mere 21%. The air is predominated by Nitrogen and other gasses at negligible levels. When people are critically ill or have chronic lung disease, they often require additional oxygen to oxygenate the blood and tissues properly. In extreme cases, a patient may require 100 percent oxygen. That is to say that they are breathing in pure oxygen.

Like all drugs, too much oxygen can be harmful and dangerous. Table 2 lists the side effects of excessive exposure to oxygen. There is still debate as to how much oxygen is too much oxygen. We do know that high concentrations of oxygen over a while can cause an overproduction of free radicals in the lungs. If unchecked, these radicals can severely damage or kill lung tissue. If left for a prolonged period, the patient can suffer permanent lung damage. The general rule is that a patient should be on the least amount of oxygen necessary to keep their blood-oxygen levels high enough to supply the tissues and organs adequately. [14]

Table 2: Side effects of excess supply of oxygen

Headache	Disorientation	Cold shivering
Irritability & Anxiety	Hyperventilation	Fatigue
Dizziness	Hiccups	Tingling in the limbs
Visual changes such as blurring and tunnel vision	Tinnitus and Hearing disturbances	Nausea
Twitching	Tonic-clonic seizure	

Source: NIH [15]

OXYGEN & ALTITUDE SICKNESS

Climbers of high altitudes, such as in mountain explorations, commonly have breathing uneasiness and other issues and require specialized gear. As altitude increases, atmospheric pressure enters into the picture, and the quantum of oxygen in the air per breath taken will tend to become lower. A kind of sickness called Altitude Sickness or Mountain Sickness comes in, and this is commonly visible amongst mountain tourists. Common health issues because of mountain/altitude sickness include nausea, headache, and fatigue at the primary level. Prolonged such exposures can lead to severe illness and require hospitalization.[16] Demographics, speed of ascending, season, altitude, the distance of the altitude from the equator, and other factors also affect the medical conditions. A severe form of sickness called acute mountain sickness (AMS) that is visible amongst mountaineers will have self-limiting symptoms visible 6–12 h after an ascent of 2500 m or more, and these symptoms generally subside by 2–3 days of stay. [17]

IMPORTANCE OF SAFE HANDLING OF OXYGEN CYLINDERS

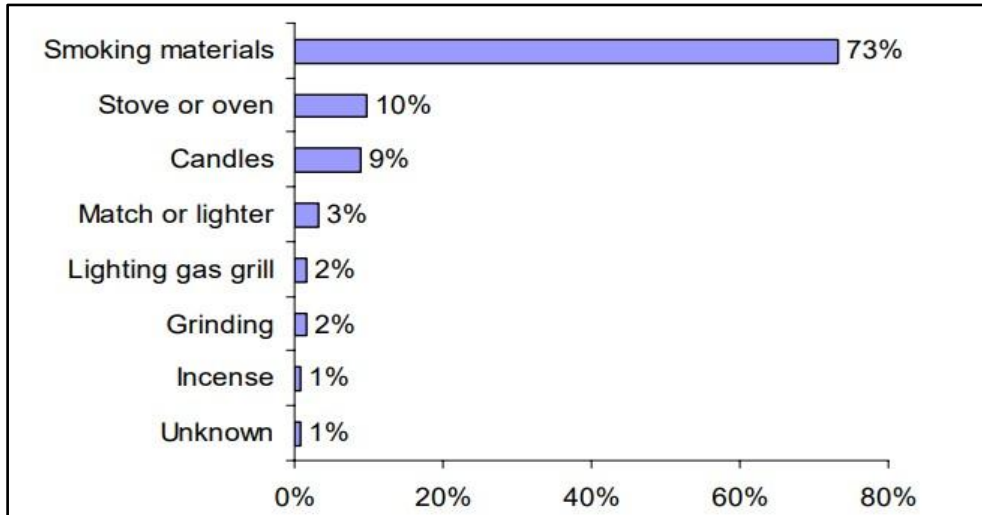
Compressed Medical Oxygen (Oxygen IP) is a medical drug and is used in a range of healthcare applications - from anesthesia to inhalation therapy. This oxygen will be compressed at high pressure in the cylinder for storage and transportation.

Oxygen cylinders are coded depending on the compression levels of the gas. Normally, A-type, B-type, and D-type are compressed medical oxygen cylinders having 150 bar pressure with oxygen acting as an oxidizing agent. Accidental fire catching the oxygen will make it contract in a big way and thereby become hazardous. Improper operation of pressurized oxygen cylinders will turn them into missiles and might even lead to blasts that can prove to be fatal. Several incidents and tragedy stories were reported across the world.

One of the biggest risks with oxygen cylinders is that, if not handled properly, they behave like missiles. This is mainly on account of pressure with which the oxygen is compressed inside the cylinder.[18] Oxygen gas, by its nature, does not burn. However, it acts like an oxidizer - one that supports the process of combustion. So, if a flame comes close by the cylinder, it feeds to flames and can potentially blast or cruise like a missile. The impact is so powerful that it can explode a residential building. Even a candle or a gas stove flame close by can become a

potential trigger for a blast. Hence, the cylinders should always be kept away from flammable objects. Further, the fire that catches up will be alive until the entire oxygen in the cylinder is consumed. So, a large capacity oxygen cylinder, if blasted, would typically be exceedingly difficult to control. Chart 1 shows the common source of Heat Source in 2003-2006 Medical Oxygen-Related Burns seen at Hospital Emergency Rooms.

Chart 1: Heat source for Medical Oxygen-related Burns Seen at Hospital Emergency Rooms



Source: CPSC's National Electronic Injury Surveillance System

During 2003-2006, hospital emergency rooms saw an estimated average of 1,190 thermal burns per year caused by ignitions associated with home medical oxygen. As many as Eighty-nine percent of the victims suffered facial burns and, in most cases, the fire department was not involved. [19]

It is common amongst patients to use home oxygen concentrators, but they are of limited capacity – adequate for individual use. The oxygen concentrators used at hospitals are bigger and delivers 95 percent oxygen USP. When a disaster happens, there is an urgent meeting of the gas supply committee to assess the available oxygen supply. Elective procedures that require oxygen should be suspended until adequate external supply reaches. Assessment to determine the remaining time to end of supply should be done. The use of telemetry can be useful in tracking and initiating supply for both hospitals and vendors. They also have a table that helps estimate the number of days of oxygen stock needed depending on the distance from the liquid oxygen plant and the telemetry availability.[20]

OXYGEN CYLINDERS DURING COVID-19 PANDEMIC

The usage of oxygen gas gained prominence for being a prescribed item in the treatment during COVID-19 times. Boosting oxygen supply is found useful in many low and middle-income countries. Oxygen infrastructure setup and maintenance are a part of the hospital setup. Hospitals in these countries have to balance immediate needs and the long-term cost-effectiveness of medical oxygen at healthcare facilities. [21] Oxygen therapy is a treatment in which the patient is given excess oxygen to facilitate easy breathing. This should be performed in the presence and instructions of trained physicians; however, as both high and low oxygen concentrations in the blood are harmful and should be monitored when administered to the human body. Thus, patients who could procure an oxygen cylinder at home should still refrain from using it themselves.[22] Media sources claimed that some patients are hoarding the cylinders in a bid to sell at higher prices to monetize the shortage situation. The act is not only immoral, illegal but also dangerous. Governments across the world insist that each oxygen cylinder be supplied, transported, and delivered to the end customer, who typically are hospitals or industrial establishments, by licensed manufacturers. Thus, hoarding oxygen cylinders is a punishable crime. Media reports across several countries have reported a three times hike in the price of oxygen cylinders. Stricter regulation and enforcement of oxygen cylinders are essential to prevent hoarding and the creation of artificial demand. Table 3 shows the business of select oxygen gas manufacturers/suppliers.

Table 3: List of leading oxygen gas manufacturers/suppliers and their business during COVID-19

Company Name	Business pre/during COVID-19 times
Linde	The healthcare segment represents 21% of company sales – 4 percent sales growth in YoY terms. Higher medical oxygen volumes are reported, particularly in Latam. Company is ramping up homecare services in Europe & US [23]
Air Liquide	1.7 M patients with chronic diseases are treated at home by Air Liquide in 2019.[24] 17% of business revenue is from the healthcare business.[25] Concerning H1 FY2021, globally, strong sales in Medical Oxygen are offset with the postponement of elective procedures. Hygiene products and Ventilator manufacturing demand continued to increase. In Europe, greater than 10% increase in sales driven by Hygiene & Equipment but reported lower sales of medical oxygen. Regarding HHC, fewer installations of new patients in sleep apnea & diabetes during the crisis. Sales in the Americas improved lead by the US (at the end of Q2) and in Latin America. [26]
Air Water	97 percent YoY growth in revenues and 58.6 percent increase in operating profit in FY2020. [27]
Taiyo Nippon Sanso	The company acquired IMI Co., Ltd., a medical equipment sales company. [28]

REGULATIONS

Currently, the information about the purchases of oxygen cylinders and related equipment is mostly not adequately maintained. This could become a colossal lapse if left not collected. Different countries have partially dealt with this information necessity. Taking a step forward, the Divisional Clinical Management Committee of Indore, India, asked the local health department to collect information about purchasers of oximeters and oxygen cylinders from medical outlets.[29] There were instances where the US Food and Drug Administration took action at erring medical gas makers. [30]

SUGGESTIONS

1. Oxygen gas requires stringent regulations, and suitable legislative enactments should be made to restrict its direct access.
2. Patients should take the supervision by the medical doctor when they are advised to use or store compressed medical oxygen (Oxygen IP) cylinders at home.
3. Patients should be strongly suggested not to keep oxygen cylinders unnecessarily, mainly when scarcity and demand are there from oxygen suppliers to cater to hospitals, especially in COVID-19 pandemic situations.
4. In the form of advertisements/commercials, quizzers, and webinars, awareness campaigns are to be carried out in similar lines to other hazardous gases, such as that of LPG.
5. Researchers in the finance domain can consider studying the impact of oxygen gas sales for COVID-19 cases as against (opportunity) loss of sales because of postponement of non-emergency medical cases

CONCLUSION

Several individuals and the elderly are intending and forcing oxygen providers to provide oxygen cylinders for residence use. While this is done to avoid the rush for oxygen in case an emergency arises, particularly in the situation of COVID-19 pandemic, individuals need to understand the various issues involved in such storage. They have to check whether they are eligible to store these high-pressure cylinders at homes in the first place. Information presented in this article is intended to provide knowledge about oxygen and to make aware of oxygen concentrations and levels, which affects health when unsafe handling practices take place. This paper intends to provide awareness of the few advantages and several disadvantages of storing them. Perspectives from both legal and safety aspects are included.

COMPLIANCE WITH ETHICAL STANDARDS

There were no humans or animals involved in this research, and the authors have complied with ethical standards of research.

CONFLICTS OF INTERESTS

The first author, being an entrepreneur, is involved in transportation and distribution of oxygen and other gasses to various institutions. The other authors declare that there are no conflicts of interest concerning the research, data, authorship, or publication of this article.

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