

## Medical Oxygen Safe Handling During Coronavirus Pandemic: Short Review

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### Abstract

**Background:** When oxygen is mentioned, we think of air that we inhale. However, oxygen that is used for medical purposes and treatments should be highly pure (> 99.5 %). **Materials and Methods:** Medical oxygen can be used for oxygen therapy, anesthetics, resuscitation, and life support. Using excess oxygen could cause several side effects, including nasal irritation, hypoxic respiratory drive, and pulmonary oxygen toxicity. **Results:** During the COVID-19 pandemic, while there is an increasing demand for medical oxygen, it can be concluded that a number of health care centers are not equipped to handle oxygen cylinders in a safe way. Also, the household use of oxygen cylinders can be considered as a new risk in terms of the lack of safe use of compressed gases. **Conclusion:** Several precautions and some case studies are reported in this paper, mainly are the basic recommendations for safe medical oxygen gas handling.

### 1. Introduction

Oxygen is the main reason for life continuity; simply, we breathe it every few seconds to fulfill our biological activities. Many people think that air is oxygen, but the fact is oxygen represents 21% of the air in the atmosphere. Indeed, in addition to oxygen, atmospheric air contains about 78% nitrogen and 1% variety of other gases like carbon dioxide and argon [1]. Because nitrogen owns a lower boiling point than oxygen, it boils faster than other liquid air components, and departing oxygen and argon behind. Liquid oxygen color is pale blue, which freezes at  $-219\text{ }^{\circ}\text{C}$  and boils at  $-183\text{ }^{\circ}\text{C}$  [2]. Compressed medical gases (CMG) contain two forms, gaseous and liquid (cryogenic), where the liquid is stored in high-pressure cylinders and treated as a gas. Different types the CMGs are used, such as oxygen, nitrogen, nitrous oxide, medical air, carbon dioxide, helium, and mixtures of these gases [3]. Medical oxygen cylinders must contain a compressed oxygen gas with a minimum purity of 99.5 % [4]. Medical oxygen can be used in oxygen therapy, anesthetics, resuscitation, and life support; while industrial oxygen has less purity and is applied in a wide range of industrial applications, including combustion, oxidation, cutting, and chemical reactions [5].

However, oxygen supplied to patients cannot be expected to be a dangerous gas at normal conditions, but once the provided amount is high, side effects, particularly

on the lungs, are possibly taking place. Hence, administering the supplied oxygen to patients is important and patient's vitals are important to be monitored. An excess amount of oxygen could result in different side effects of nasal irritation, hypoxic respiratory drive, and pulmonary oxygen toxicity [1].

bilayer lipid-containing copied nucleocapsids attached to an RNA Genome and taking a bead-string shape. The pins on the surface stick hardly on the human cells; hence, changes occur on the cell's surface, and the virus membrane merges within the cell's one. Once the virus is in, it can copy itself and cause it [3,4].

Cylinder's labels are the main way of identifying the cylinder contents. In case of damaging or missing the label, it is recommended to never use the cylinder in any circumstance. Instead, return it to the gas company for a replacement. Cylinder's color is a second way to identify the cylinder contents and the type of hazards associated with the gas-filled within the cylinder. In terms of personal safety, it is mandatory that customers be familiarized with the material safety data sheets (MSDS), gas equipment operation, and manuals [6]. Figure 1 shows a type of compressed oxygen label [7].



Figure 1. A type of compressed oxygen label.

The gas cylinders store is a place that contains full and empty gas cylinders, where full cylinders are stored in stock and the empty ones are kept until they are taken by the gas companies. Gas cylinders are required to maintain upright on a straight floor and must be secured from falling. The valves have to be tightly closed and the cylinder caps have to be fully screwed on. All cylinders are required to be away from any source of heat or radiation by minimally 0.5 m. Stores are needed to be private and placed at critical areas of emergency routes, garages, stairways, corridors, etc. However, refilling and repairing the cylinders are not allowed in stores [8].

## 2. Safety Guidelines

Many gases are classified as dangerous once they are not handled well, and oxygen is one of them. A high concentration of oxygen can result in burning and in particular could cause an explosion. The followings are several basic safety guidelines that needed to be followed in case of handling any type of oxygen cylinders: Retain the cylinder in the upright situation all the time. Keep oxygen cylinder away from heat sources, such as fireplaces, ovens, stoves, radiators, etc. Sparking a flame is completely forbidden in any place where oxygen is in operation. It is recommended to not use oxygen for patients without a doctor's prescription. Finally, keep oxygen cylinders in an air-ventilated area to avoid leakage risks [1].

## 3. Oxygen Concentration

Oxygen content in the atmosphere was not constant over the last billion years; it ranged from 3 to 35% as shown in Figure 2 [9]. However, it turns out that the oxygen level at the present time is 21%.

It was reported that a tiny increase in oxygen content, up to 24 %, in the atmosphere leads to hazardous circumstances. Consequently, it will be easier to start a fire that burns hotter and stronger than the recent normal air, where it could be nearly impossible to extinguish the fire. A leaking hose, instrument, and/or valve in a closed area/room or with a poor ventilation room leading to increase the oxygen concentration fast to a serious level [10]. Oxygen is heavier than air mixture; hence, higher concentrations of it can be found in low-level areas of ditches, pits, and underground rooms, especially when air circulation is unavailable. This situation is more relevant to liquid oxygen spilling, where the cold oxygen gas is three times denser than air. The three elements that are required to have a fire or explosion to take

place are combustible material, spark source, and oxygen. These are commonly called the fire triangle, where missing one of them is enough to inhibit fire [11].

There are several reasons to end up with fire and explosions when oxygen is misused, such as oxygen heavy leaking from damaged equipment, using inappropriate materials with oxygen, using oxygen in instruments that were not designed for its purposes, and wrong or neglectful operation of oxygen tools and devices [10].

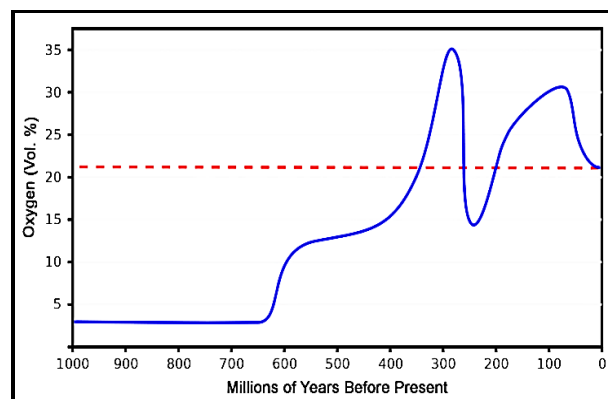


Figure 2. Oxygen content of the atmosphere over the last billion years.

## 4. Precautions for Safe Handling

It is recommended to keep the oxygen containers away from any lighting sources, even those of static charges. Also, only proper and specified equipment that is competent for this gas should be used. Furthermore, smoking is not allowed while handling oxygen cylinders, and oxygen equipment should be kept oil- and grease-free under all circumstances.

On the other side, only trained and experienced workers or persons that have knowledge about the proper instruction of handling gases should deal with oxygen under pressure. Regular checking is required to ensure that no leaks exist before use. Ultimately, Oxygen must be handled with care, following safety protocols, and in good industrial hygiene [12].

## 5. Proper Handling of Medical Oxygen Cylinders for Patients

- Before setting the cylinder next to the patient, it should be checked and its connections and valves; the valves should be turned on slowly and the desired flow rate should be selected.
- The cylinder is required to be placed in a suitably holder designed for this purpose. Also, it is recommended to avoid setting the cylinder on the patient's bed. However, in case of having no other option but putting the cylinder on the patient's bed, it is needed to ensure that the cylinder was turned on first and the needed flow was achieved.

Essentially, oxygen cylinders have to be set in specially designed holders or trolleys, in which they can be separated from direct touch with flammable materials [13].

### 6. Medical Oxygen Handling During Coronavirus Pandemic

During the recent COVID-19 pandemic, medical oxygen became widespread in most medical institutions whether these are designated for handling the gas or not. Moreover, handling and transferring oxygen cylinders was done domestically, which increases the hazard of using this gas.

Most of the oxygen cylinders found in private clinics, emergency rooms, and reception centers in hospitals are lacking the identification cards, in which the name of the gas, its chemical symbol, its concentration, purity, batch or production number, date of filling, expiration date, and the date of the last validity examination are listed. Figures 3, 4, and 5 illustrate unacceptable behaviors of handling medical oxygen cylinders.



Figure 3. Unsecured cylinders when transporting the gas.



Figure 4. Transporting gas to upper floors in this way is very dangerous.



Figure 5. A very dangerous situation when storing or transporting gas cylinders.

Nowadays, during the increasing demand for medical oxygen due to the COVID-19 pandemic, it can be said that a number of health centers, in addition to the individuals, are not equipped to handle oxygen cylinders in a large and safe manner. In a hospital, a caravan was used to install an oxygen cylinder filling unit. This site, and similar sites, does not have the necessary supplies for safe gas handling. As a result, a fire occurred that led some cylinders to explode as shown in Figures 6 and 7. Below are some cases of oxygen accidents that ended up with catastrophic results.



Figure 6. Fire and explosion in oxygen cylinder filling unit.



Figure 7. Transporting the wounded from the scene of the accident



## 7. Case Studies

### 1. Case study 1: Oxygen torch assembly lighted an explosion and resulted in a burned hand

Leakage in an oxygen hose occurred where oxygen became in contact with a hydrocarbon material (oil/grease) and yielded an explosion. This explosion caused damage to the regulator and pressure gauges (Figure 8), and burns to a hand of an employee's as shown in Figure 9.



**Figure 8.** Oxygen explosion causing damage to the regulator and pressure gauges.



**Figure 9.** Oxygen explosion caused a damage to a worker's hand

When a pressured oxygen and a hydrocarbon material (oil and/or grease) come to contact, they could react vigorously. This reaction led to generate fire, explosions, injuries or death to people, and damage to the properties. Thereby, it is not allowed for oil or grease, or any type of organic materials, to be in touch with highly pressurized oxygen even if the amounts are tiny [14].

### 2. Case study 2: Sudden oxygen release from compressed oxygen cylinder

A 25 years old track driver was transferring a large full oxygen cylinder to his track, helped with two other workers

at an oxygen manufacturing company as shown in Figure 10. He loaded the oxygen cylinder manually taking no care about safety procedures and using no transferring tools, such as trolleys. Instead, he rolled the cylinder in a slope where the pressure valve faced his belly. Accidently, the pressure valve fell off, the pressurized gas broke open through the outlet and hit his stomach area straightly. He was found around 20 feet away from the accident location and he immediately died (see Figure 11). Although there was no fire and the cylinder had no damage except for the pressure valve, the explosion was intensive and caused death [15].



**Figure 10.** Loading large completely filled compressed oxygen cylinder to lorry.



**Figure 11.** A lorry driver thrown about 20 feet away by the pressure of compressed oxygen gas.

### 3. Case study 3: A terrible accident in a hospital in Baghdad dedicated to COVID-19 patients

As we put the last case in this research, Baghdad was struck on the evening of April 24<sup>th</sup>, 2021 with a tragic fire accident in Ibn Alkhateeb hospital which is dedicated to receiving the critical cases of COVID-19 patients. The fire was followed by an explosion of oxygen cylinders. The accident

led to 82 deaths and 110 injuries as a result of burning, suffocation, and lack of oxygen; though the numbers are expected to increase. This accident is an example of what was previously mentioned about the lack of infrastructure requirements in the health centers and hospitals to handle and store oxygen cylinders securely. This comes along with the great lack of knowledge for individuals for safely handling medical oxygen gas cylinders. Figures 12, 13, and 14 illustrate some scenes describing the accident.



**Figure 12.** A great fire in the hospital.



**Figure 13.** Comprehensive destruction of oxygen systems.



**Figure 14.** Extinguishing the secondary ceilings that led to the spread of the fire.

## 8. Recommendations for Using Oxygen During COVID-19 Pandemic

Currently, we are facing a coronavirus called SARS-CoV-2 that started in China and spread globally [16,17]. This virus affected elderly people more than children and puts them in critical situations due to the decrease in oxygen levels in their blood [18,19]. As long as the COVID-19 pandemic continues and the number of infected people is increasing in many countries, it mainly requires providing medical oxygen in line with the increasing need for this gas. It requires spreading awareness and education on all safety measures that ensure the safe handling of compressed gas cylinders and upgrading the infrastructure of health centers, making them safe sites for medical oxygen handling. In Iraq, the number of cases is considered high due to different reasons that related to the society or environmental pollution [20,21]. Hence, an educational culturing program is required to teach people how to protect themselves.

## 9. Conclusion

Within a year and a half of the spread of SARS-CoV-2 virus around the world at varying degrees, the need for medical oxygen has emerged to treat patients who suffer from weak lung function and shortness of breath resulting from the direct effect of the virus on the lungs. Many health institutions lack the technical and logistical capabilities to deal with oxygen cylinders and their safe handling. In addition, the widespread domestic use of these cylinders is considered as another source of danger, which created new risks that may affect the ignorant user who deals with this gas. Here, it is recommended to spread the culture of dealing with oxygen cylinders among people and workers to avoid the accidents.

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## Conflicts of Interest

The authors declare that there is no conflict of interest.

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