Oxygen therapy

**Oxygen therapy** is the administration of oxygen as a medical intervention, which can be for a variety of purposes in both chronic and acute patient care. Oxygen is essential for cell metabolism, and in turn, tissue oxygenation is essential for all normal physiological functions.\[3\]

Room air only contains 21% oxygen, and increasing the fraction of oxygen in the breathing gas increases the amount of oxygen in the blood. It is often only required to raise the fraction of oxygen delivered to 30–35% and this is done by use of a nasal cannula. When 100% oxygen is needed, it may be delivered via a tight-fitting face mask, or by supplying 100% oxygen to an incubator in the case of infants. Oxygen can be administered in other ways, including specific treatments at raised air pressure, such as hyperbaric oxygen therapy.

High blood and tissue levels of oxygen can be helpful or damaging, depending on circumstances and oxygen therapy should be used to benefit the patient by increasing the supply of oxygen to the lungs and thereby increasing the availability of oxygen to the body tissues, especially when the patient is suffering from hypoxia and/or hypoxaemia.

**Indications for use**

Oxygen is used as a medical treatment in both chronic and acute cases, and can be used in hospital, pre-hospital or entirely out of hospital, dependant on the needs of the patient and the views of the medical professional advising.

**Use in chronic conditions**

A common use of supplementary oxygen is in patients with chronic obstructive pulmonary disease (COPD), a common long term effect of smoking, who may require additional oxygen to breathe either during a temporary worsening of their condition, or throughout the day and night. It is indicated in COPD patients with PaO\(_2\) ≤ 55mmHg or SaO\(_2\) ≤ 88% and has been shown to increase lifespan.\[4\]
Use in acute conditions

Oxygen is widely used in emergency medicine, both in hospital and by emergency medical services or advanced first aidsers.

In the pre-hospital environment, high flow oxygen is definitively indicated for use in resuscitation, major trauma, anaphylaxis, major haemorrhage, shock, active convulsions and hypothermia.\[^3\][^5]

It may also be indicated for any other patient where their injury or illness has caused hypoxaemia, although in this case oxygen flow should be moderated to achieve target oxygen saturation levels, based on pulse oximetry (with a target level of 94-98% in most patients, or 88-92% in COPD patients).\[^3\]

For personal use, high concentration oxygen is used as home therapy to abort cluster headache attacks, due to its vaso-constrictive effects.\[^6\]

Storage and sources

Oxygen can be separated by a number of methods, including chemical reaction and fractional distillation, and then either used immediately or stored for future use. The main types sources for oxygen therapy are:

1. Liquid storage - Liquid oxygen is stored in chilled tanks until required, and then allowed to boil (at a temperature of 90.188 K (−182.96 °C)) to release oxygen as a gas. This is widely used at hospitals due to their high usage requirements, but can also be used in other settings. See Vacuum Insulated Evaporator for more information on this method of storage.

2. Compressed gas storage - The oxygen gas is compressed in a gas cylinder, which provides a convenient storage, without the requirement for refrigeration found with liquid storage. Large oxygen cylinders hold 6500 litres (230 cu ft) and can last about two days at a flow rate of 2 litres per minute. A small portable M6 (B) cylinder holds 164 or 170 litres (5.8 or 6.0 cu ft) and weighs about 1.3 to 1.6 kilograms (2.9 to 3.5 lb).\[^7\] These tanks can last 4–6 hours when used with a conserving regulator, which senses the patient's breathing rate and sends pulses of oxygen. Conserving regulators may not be usable by patients who breathe through their mouths.

3. Instant usage - The use of an electrically powered oxygen concentrator\[^8\] or a chemical reaction based unit\[^9\] can create sufficient oxygen for a patient to use immediately, and these units (especially the electrically powered versions) are in widespread usage for home oxygen therapy and portable personal oxygen, with the advantage of being continuous supply without the need for additional deliveries of bulky cylinders.

Delivery
Various devices are used for administration of oxygen, from whichever source. In most cases, the oxygen will first pass through a pressure regulator, used to control the high pressure of oxygen delivered from a cylinder (or other source) to a lower pressure. This lower pressure is then controlled by a flowmeter, which may be preset or selectable, and this controls the flow in a measure such as litres per minute (lpm). The typical flowmeter range for medical oxygen is between 0 and 15 lpm with some units able to obtain up to 25 liters per minute. Many wall flowmeters using a "thorpe tube" style design are able to be dialed to "flush" which is beneficial in emergency situations.

**Supplemental oxygen**

Many patients require only a supplementary level of oxygen in the room air they are breathing, rather than pure or near pure oxygen, and this can be delivered through a number of devices dependant on the situation, flow required and in some instances patient preference.

A nasal cannula (NC) is a thin tube with two small nozzles that protrude into the patient's nostrils. It can only comfortably provide oxygen at low flow rates, 2-6 litres per minute (LPM), delivering a concentration of 24-40%.

There are also a number of face mask options, such as the simple face mask, often used at between 6 and 12 LPM, with a concentration of oxygen to the patient of between 28% and 50%. This is closely related to the more controlled air-entrainment masks, also known as Venturi masks, which can accurately deliver a predetermined oxygen concentration to the trachea up to 40%.

In some instances, a partial rebreathing mask can be used, which is based on a simple mask, but featuring a reservoir bag, which increases the provided oxygen rate to 40-70% oxygen at 5 to 15 LPM.

**High flow oxygen delivery**

In cases where the patient requires a flow of up to 100% oxygen, a number of devices are available, with the most common being the non-rebreather mask (or reservoir mask), which is similar to the partial rebreathing mask except it has a series of one-way valves preventing exhaled air from returning to the bag. There should be a minimum flow of 10 L/min. The delivered FIO2 of this system is 60-80%, depending on the oxygen flow and breathing pattern.

High flows of warmed and humidified air/oxygen blends can also be delivered via a nasal cannula, allowing the patient to continue to talk, eat and drink while still receiving the therapy.

In specialist applications such as aviation, tight fitting masks can be used, and these also have applications in anaesthesia, carbon monoxide poisoning treatment and in hyperbaric oxygen therapy.
Positive pressure delivery

Patients who are unable to breathe on their own will require positive pressure to move oxygen in to their lungs for gaseous exchange to take place. Systems for delivering this vary in complexity (and cost), starting with a basic pocket mask adjunct which can be used by a basically trained first aider to manually deliver artificial respiration with supplemental oxygen delivered through a port in the mask.

Many emergency medical service and first aid personnel, as well as hospitals, will use a bag-valve-mask (BVM), which is a malleable bag attached to a face mask (or invasive airway such as an endotracheal tube or laryngeal mask airway), usually with a reservoir bag attached, which is manually manipulated by the healthcare professional to push oxygen (or air) in to the lungs. This is the only procedure allowed for initial treatment of cyanide poisoning in the UK workplace.\[14\]

Automated versions of the BVM system, known as a resuscitator or pneupac can also deliver measured and timed doses of oxygen direct to patient through a facemask or airway. These systems are related to the anaesthetic machines used in operations under general anaesthesia that allows a variable amount of oxygen to be delivered, along with other gases including air, nitrous oxide and inhalational anaesthetics.

As a drug delivery route

Oxygen therapy can also be used as part of a strategy for delivering drugs to a patient, with the usual example of this being through a nebulizer mask, which delivers nebulizable drugs such as salbutamol or epinephrine into the airways by creating a vapor-mist from the liquid form of the drug.

Filtered oxygen masks

Filtered oxygen masks have the ability to prevent exhaled, potentially infectious particles from being released into the surrounding environment. These masks are normally of a closed design such that leaks are minimized and breathing of room air is controlled through a series of one-way valves. Filtration of exhaled breaths is accomplished either by placing a filter on the exhalation port, or through an integral filter that is part of the mask itself. These masks first became popular in the Toronto (Canada) healthcare community during the 2003 SARS Crisis. SARS was identified as being respiratory based and it was determined that conventional oxygen therapy devices were not designed for the containment of exhaled particles.\[14\] \[15\] \[16\] \[17\] Common practices of having suspected patients wear a surgical mask was confounded by the use of standard oxygen therapy equipment. In 2003, the HiOx\[^80^\] oxygen mask was released for sale. The HiOx\[^80^\] mask is a closed design mask that allows a filter to be placed on the exhalation port. Several new designs have emerged in the global healthcare community for the containment and filtration of potentially infectious particles. Other designs include the ISO-O\(^2\) oxygen mask, the Flo\(_2\)Max oxygen mask, and the O-Mask. The use of oxygen masks that are capable of filtering exhaled particles is gradually becoming a recommended practice for pandemic preparation in many jurisdictions.

Because filtered oxygen masks use a closed design that minimizes or eliminates inadvertent exposure to room air, delivered oxygen concentrations to the patient have been found to be higher than conventional non-rebreather masks, approaching 99% using adequate oxygen flows. Because all exhaled particles are contained within the mask, nebulized medications are also prevented from being released into the surrounding atmosphere, decreasing the occupational exposure to healthcare staff and other patients.
Negative effects

Many EMS protocols indicate that oxygen should not be withheld from any patient, while other protocols are more specific or circumspect. However, there are certain situations in which oxygen therapy is known to have a negative impact on a patient's condition. [18]

Oxygen should never be given to a patient who is suffering from paraquat poisoning unless they are suffering from severe respiratory distress or respiratory arrest, as this can increase the toxicity. (Paraquat poisoning is rare - for example 200 deaths globally from 1958–1978). [19] Oxygen therapy is not recommended for patients who have suffered pulmonary fibrosis or other lung damage resulting from bleomycin treatment. [20]

High levels of oxygen given to infants causes blindness by promoting overgrowth of new blood vessels in the eye obstructing sight. This is retinopathy of prematurity (ROP).

Oxygen has vasoconstrictive effects on the circulatory system, reducing peripheral circulation and was once thought to potentially increase the effects of stroke. However, when additional oxygen is given to the patient, additional oxygen is dissolved in the plasma according to Henry's Law. This allows a compensating change to occur and the dissolved oxygen in plasma supports embarrassed (oxygen-starved) neurons, reduces inflammation and post-stroke cerebral edema. Since 1990, hyperbaric oxygen therapy has been used in the treatments of stroke on a worldwide basis. In rare instances, hyperbaric oxygen therapy patients have had seizures. However, because of the aforementioned Henry's Law effect of extra available dissolved oxygen to neurons, there is usually no negative sequel to the event. Such seizures are generally a result of oxygen toxicity, [21] [22] although hypoglycemia may be a contributing factor, but the latter risk can be eradicated or reduced by carefully monitoring the patient's nutritional intake prior to oxygen treatment.

Oxygen first aid has been used as an emergency treatment for diving injuries for years. [23] Recompression in a hyperbaric chamber with the patient breathing 100% oxygen is the standard hospital and military medical response to decompression illness. [23] [24] [25] The success of recompression therapy as well as a decrease in the number of recompression treatments required has been shown if first aid oxygen is given within four hours after surfacing. [26] There are suggestions that oxygen administration may not be the most effective measure for the treatment of decompression illness and that heliox may be a better alternative. [27]

Chronic obstructive pulmonary disease

Care needs to be exercised in patients with chronic obstructive pulmonary disease, such as emphysema, especially in those known to retain carbon dioxide (type II respiratory failure). Such patients may further accumulate carbon dioxide and decreased pH (hypercapnation) if administered supplemental oxygen, possibly endangering their lives. [28] This is primarily as a result of ventilation–perfusion imbalance (see Effect of oxygen on chronic obstructive pulmonary disease). [29] In the worst case, administration of high levels of oxygen in patients with severe emphysema and high blood carbon dioxide reduces respiratory drive to the point of precipitating respiratory failure, and eventual death. However the risk of the loss of respiratory drive are far outweighed by the risks of withholding emergency oxygen, and therefore emergency administration of oxygen is never contraindicated. Transfer from field care to definitive care, where oxygen use can be carefully calibrated, typically occurs long before significant reductions to the respiratory drive.

A recent study has shown that titrated oxygen therapy (controlled administration of oxygen) may be more appropriate for COPD patients, and less of a danger to them. [28] The study also showed that other, non-COPD patients, may also, in some cases, benefit more from titrated therapy. However, the results are not conclusive, and may have no statistical relevance when adjusted for proper protocol usage. [30]
Fire risk

Highly concentrated sources of oxygen promote rapid combustion. Fire and explosion hazards exist when concentrated oxidants and fuels are brought into close proximity; however, an ignition event, such as heat or a spark, is needed to trigger combustion.[31] Oxygen itself is not the fuel, but the oxidant. Combustion hazards also apply to compounds of oxygen with a high oxidative potential, such as peroxides, chlorates, nitrates, perchlorates, and dichromates because they can donate oxygen to a fire.

Concentrated $O_2$ will allow combustion to proceed rapidly and energetically.[31] Steel pipes and storage vessels used to store and transmit both gaseous and liquid oxygen will act as a fuel; and therefore the design and manufacture of $O_2$ systems requires special training to ensure that ignition sources are minimized.[31]

Hospitals in some jurisdictions, such as the UK, now operate “no-smoking” policies, which although introduced for other reasons, supports the aim of keeping ignition sources away from medical piped oxygen. Other recorded sources of ignition of medically prescribed oxygen include candles, aromatherapy, medical equipment, cooking, and unfortunately, deliberate vandalism. Smoking pipes, cigars and cigarettes are of special concern. This does not entirely eliminate the risk of injury with portable oxygen systems, especially if compliance is poor.[32]

Oxygen therapy while on aircraft

In the United States, most airlines restrict the devices allowed on board aircraft. As a result passengers are restricted in what devices they can use. Some airlines will provide cylinders for passengers with an associated fee. Other airlines allow passengers to carry on approved portable concentrators. However the lists of approved devices varies by airline so passengers need to check with any airline they are planning to fly on. Passengers are generally not allowed to carry on their own cylinders. In all cases, passengers need to notify the airline in advance of their equipment.

Effective May 13th, 2009 the Department of Transportation and FAA ruled that a select number of portable oxygen concentrators are approved for use on all commercial flights.[33] The list of approved portable oxygen concentrators includes the Respironics EverGo, the Invacare XPO2, the Invacare Solo 2 and others[34].

FAA regulations require larger airplanes to carry D-cylinders of oxygen for use in an emergency.

References

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[19] Experience with parquat poisoning in a respiratory intensive care unit in North India (http://www.sma.org.sg/smj/4712/4712a2.pdf)
[33] http://www.faa.gov/about/initiatives/cabin_safety/porable_oxygen/
[34] http://www.open-air.eireentalcenter/

External links

• American Association for Respiratory Care Clinical Practice Guideline: Oxygen Therapy for Adults in the Acute Care Facility — 2002 Revision & Update (http://www.rcjournal.com/cpgs/otchcpg-update.html)
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