Fundamentals of oxygen therapy

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Oxygen therapy is the term we use for the clinical use of supplemental oxygen. It’s indicated in patients with acute hypoxemia (PaO₂ less than 60 mm Hg or SaO₂ less than 90%) and those with symptoms of chronic hypoxemia or increased cardiopulmonary workload. Oxygen is also given to help with the removal of loculated air in the chest, as you would see with pneumothorax or pneumomediastinum.

In the ED setting, it’s part of the protocols for CPR, treatment of carbon monoxide poisoning, and cyanide toxicity (see Sample indications for oxygen supplementation).

As with all therapies, risks and benefits need to be considered. For example, patients with chronic respiratory failure depend on their hypoxic drive to breathe. Hypoxia is a major determinant of morbidity and mortality in critically ill patients.

Adequate oxygenation and tissue perfusion are vital to survival.

Many disease processes can produce hypoxemia. In the acute care setting, the most common mechanism for hypoxemia is ventilation-perfusion mismatch. Other mechanisms include hypoventilation, right to left shunt, and diffusion abnormality (see Mechanisms of hypoxemia).

Assessing patients for oxygen therapy

The initial needs assessment for oxygen therapy is made clinically, considering what we see when we evaluate the patient, lab findings, and what we know about the underlying disease process. Pay particular attention to three systems when addressing the potential need for oxygen therapy. Typically, we jump to the respiratory system and look for respiratory signs and symptoms, which may include alteration in rate (tachypnea, bradypnea, or apnea) or depth of respiration (hypopnea), difficulty breathing (dyspnea), and changes in color (pallor or cyanosis). However, neurologic signs and symptoms, as well as cardiac response, can provide important clues that will help direct your search for hypoxemia.

Examples for changes in neurologic status associated with hypoxemia can range from irritability and changes in level of alertness in acute settings to complaints of chronic headaches in patients with long-standing hypoxemia. The heart may respond to hypoxia by increasing or decreasing its rate, depending on the severity of the hypoxic insult. BP may be elevated early on and then become markedly decreased if the hypoxic insult is severe.

Sample indications for oxygen supplementation

- CPR
- PaO₂ less than 60 mm Hg or SaO₂ less than 90%
- Patients with symptoms of chronic hypoxemia or increased cardiopulmonary workload
- Carbon monoxide poisoning
- Cyanide toxicity
- Acute myocardial infarction
The pulse oximeter is a noninvasive device that can be used to measure oxygen saturation. This technique utilizes the oxyhemoglobin dissociation curve, which will shift with changes in temperature, pH, or different types of hemoglobin. Arterial blood gases are obtained by arterial puncture and provide information about acid-base balance, specifically pH, PaCO2, PaO2, and bicarbonate levels.

Choosing the right delivery system

Use the three P approach (Purpose, Patient, and Performance). For example, critically ill patients often need a stable, high FiO2. High flow delivery systems aren’t patient dependent and will provide a more stable and consistent delivery of oxygen. Some patients, especially children, may not tolerate masks and you’ll need to explore alternative options. You should be familiar with the performance characteristics of all of the patient care equipment you use.

From a practical point of view, there are two types of delivery systems: those for patients who are breathing on their own and can protect their airways and those for intubated or tracheostomized patients.

For patients who aren’t intubated and don’t require airway protection, you can choose from a variety of high- or low-flow options or consider an enclosure device. The following are commonly used devices:

- The nasal cannula is a comfortable delivery system for patients. It doesn’t interfere with talking or eating and comes in sizes appropriate for all age groups. It can deliver FiO2 levels of 0.24 to 0.40 with flow rates up to 8 L/minute in adults. Remember that the amount of oxygen delivery may vary according to inspiratory time and rate and depth of respiration. A good rule of thumb is that for each liter of oxygen provided, the FiO2 should increase by approximately 4%. In infants, flow rates shouldn’t exceed 2 L/minute. You’ll see nasal cannulas utilized for both short- and long-term oxygen delivery.

- The simple face mask is more cumbersome. Some patients complain of feeling claustrophobic with masks, and they must be removed before meals. For these reasons, you’ll see them used for short-term oxygen delivery. Simple face masks can provide FiO2 levels between 0.35 and 0.50. Be careful with patients with chronic obstructive pulmonary disease (COPD) and carbon dioxide (CO2) retention. Low flow rates can cause rebreathing and increased levels of CO2.

- The partial rebreathing mask can provide oxygen supplementation between 40% and 70%, with variable stability. This bag requires a minimum flow of 10 L/minute to prevent bag collapse on inspiration. Failure to ensure that the bag is inflated poses a suffocation hazard.

- The nonrebreathing mask can be used over the full range of FiO2. As with the partial rebreather, it poses a suffocation risk if not used properly.

- The air entrainment mask is used with high-flow oxygen to provide fixed FiO2 levels between 0.24 and 0.50. It’s recommended for use in unstable patients who need stable, low levels of oxygen.

- Enclosure devices, specifically oxyhoods, isolettes, and tents, are restricted to use in neonates, infants, and small children. For patients who are intubated or have a tracheostomy, additional care must be directed toward temperature control, humidification, and infection control. Remember that in these patients you’ve bypassed the

Mechanisms of hypoxemia

- Ventilation-perfusion mismatch
- Hypoventilation
- Right to left shunt
- Diffusion abnormality

did you know?
The air we breathe
At sea level, room air is composed of 20.95% oxygen, 78.09% nitrogen, 0.038% CO2, and 0.93% argon, with the remainder made up of trace gases.
upper airway. The function of the nose is to warm, filter, and humidify air.

**Use of oxygen therapy in home care**

Long-term oxygen therapy has been shown to improve survival and decrease the hospitalization rates in patients with COPD. Pulse dose oxygen delivery devices and demand oxygen delivery systems have been shown to be effective in resting, exercising, and sleeping patients. Performance characteristics may vary. It’s recommended that you become familiar with individual device specifications before using.

**Potential complications and hazards**

As with all medical therapies, the risks and benefits of using supplemental oxygen deserve your careful consideration. Potential complications of oxygen therapy include absorption atelectasis, apnea with loss of respiratory drive in patients with chronic respiratory failure, retinopathy of prematurity, and oxygen toxicity (see Potential complications of oxygen therapy). Oxygen is a potential fire hazard. In hospitals, all electrical equipment is tested; however, in the home setting it’s also important to be sure that all equipment is grounded. No smoking and no open flames should be permitted for a distance of at least 10 feet. In some cultures, it’s customary to burn incense or candles around a sickbed. This should be strictly forbidden when oxygen is in use.

Oxygen canisters and cylinders can pose a physical hazard. Cylinders should be secured, upright, chained, or in appropriate containers.

Patients using oxygen therapy require electric power. They need to have a backup generator or alternate power source in case of electrical power outage.

All related equipment should be checked and maintained in good working order because loss of oxygen therapy in a hypoxic patient could be devastating.

Heated nebulizer and aerosol generators can become ready sources of bacterial contamination. Manufacturer’s recommendations should be followed for individual devices.

**Helping patients breath easier**

In summary, oxygen supplementation is an important therapeutic modality used in both acute and chronically ill patients. Practitioners should be aware of the risks and benefits inherent in supplemental oxygen use and of the monitoring systems necessary to permit safe and effective administration. Because there are a multitude of delivery devices, adapters, ventilator systems, and resuscitation devices, you should become familiar with the equipment used in your facility and work sites. Updates are important when new equipment is purchased and periodic retraining should be incorporated into clinical nursing updates.

**Learn more about it**


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