1. Oxygen toxicity: Symptoms

Increasing partial pressure of oxygen in the blood (hyperoxia) leads to increased reactive oxygen intermediates (ROI) – superoxide anion, hydroxyl radical, and hydrogen peroxide. When cellular antioxidant defenses are depleted, these ROI's can impair cellular function, increase inflammatory response and induce apoptosis. The respiratory system and CNS are particularly susceptible to hyperoxia and produce the most clinically apparent symptoms.

Respiratory symptoms: can manifest after > 12hours of 50% FiO2 and initially consists of direct damage to respiratory tract mucosa including tracheobronchitis manifested by dry cough and hoarseness. Administration of 100% FiO2 short term can lead to atelectasis and after longer duration (>24 hours) leads to decreased vital capacity and diffuse alveolar damage.

CNS symptoms: Nausea, facial muscle twitching, tinnitus, irritability, anxiety, dizziness, seizure, visual changes including tunnel vision, myopia, direct retinal damage (Retinopathy of prematurity)

2. **Hyperbaric oxygen**

Hyperbaric oxygen therapy (HBO) is an adjunctive therapy used to treat a number of specific conditions, including acute venous or arterial gas embolism (to reduce the gas bubble size), severe carbon monoxide or cyanide poisoning, to improve wound healing (non-healing ulcers, skin grafts, etc), decompression sickness, and acute traumatic or ischemic injuries (crush, compartment syndrome, etc). The theory behind HBO revolves around Henry's Law, which states that at a constant temperature and at equilibrium, the amount of gas that dissolves in a liquid is directly proportional to its partial pressure. At sea level, i.e. 1 atm, the dissolved plasma oxygen concentration is 0.3 mL/dL, whereas hyperbaric oxygen delivered at 3 atm results in a dissolved plasma oxygen concentration of 6 mL/dL.

indication is listed below:

- Decompression sickness
- Air or gas embolism
- Carbon monoxide poisoning; cyanide poisoning; smoke inhalation
- Clostridial myostitis and myonecrosis
- Crush injuries, compartment syndromes and other acute traumatic peripheral ischemias
- Enhancement of healing in selected problem wounds
- Exceptional blood loss anaemia

- Intracranial abscess
- Necrotizing soft tissue infections
- Refractory osteomyelitis
- Compromised Skin flaps and grafts
- Delayed radiation injury (soft tissue and bony necrosis)
- Thermal burns

Hyperbaric oxygen therapy (HBO) – complications

Complications related to HBO therapy include barotrauma (middle ear, sinus, pulmonary), pulmonary oxygen toxicity, reversible myopia, and CNS oxygen toxicity (i.e. seizures). Seizures are quite rare, and studies reporting incidence are inconsistent, ranging from 1 in 50,000 to 1 in 600 patients. Patients at greatest risk are those with prior history of seizures or head trauma as well as those receiving glucocorticoids, insulin, thyroid replacement, and sympathomimetic medications. The risk is increased when patients are exposed to HBO greater than 90-120 minutes and when using pressures of 2.8-3 atm. In other words, the greatest risk is with long, sustained treatment sessions (without short intervals of room air) and using near maximal pressures.

Management of CNS oxygen toxicity seizures is terminating the HBO therapy session, decreasing the FiO2 to 0.21, giving anticonvulsant therapy, and ultimately supportive care.

Hyperbaric chamber – MAC effect

Hyperbaric oxygen (HBO) is when oxygen is delivered in an environment where the barometric pressure is more than 1 atmosphere. This is common therapy for arterial air embolism, decompression sickness, severe profound anemia or hypoperfusion, severe CO poisoning, and gas gangrene from C. perfringens. There are some fundamental gas laws to be aware of when discussing HBO.

PV = K

where P = pressure, V = volume, K = constant

- Boyle's: volume of gas is inversely proportional to pressure at constant temp.
- Gay-Lussac's: at constant volume, pressure is proportional to temp.
- Charles': at constant pressure, volume will vary directly with temp.

- Dalton's: total pressure of mixture of gases is equal to sum of partial pressures
- Henry's: at constant temp, amount of gas dissolved in liquid is proportional to partial pressure of the gas

MAC effect

Volatile agents produce anesthesia based on the partial pressure of the anesthetic in the body, not on the volume of agent in the lungs. HBO causes a decrease in MAC because there is an increase in partial pressure of the volatile agents at higher barometric pressures. There is an increase in gas density in HBO, which also causes the rotameter flowmeters to read falsely high, e.g., 2.0% sevoflurane 1 atm. would produce the same amount of anesthesia as 0.66% sevo at 3 atm.

3. **Acute mountain sickness (AMS)**

Is diagnosed clinically in a person who lives at low altitude but has recently ascended to high altitude (generally over 2000 M). Symptoms resemble those of an alcohol hangover: primarily headache often associated with fatigue, light-headedness, anorexia, nausea and vomiting, disturbed sleep, and mild shortness of breath with exertion. Onset of AMS is usually delayed for 6 to 12 hours following arrival at high altitude, but can occur as rapidly as one to two hours or as late as 24 hours.

Differential diagnoses include carbon monoxide poisoning, migraine, dehydration, exhaustion, hyponatremia, viral syndrome, alcohol hangover, bacterial infection, subarachnoid hemorrhage, stroke, and intracranial mass.

Further ascent can result in HACE (High Altitude Cerebral Edema), which includes encephalopathic symptoms and signs, including ataxic gait, severe lassitude, and progressive decline of mental function and consciousness. The mechanism is due primarily to increased cerebral vascular permeability.

Treatment

- **Conservative treatment:** Patients with AMS should avoid further ascent, limit physical activity, avoid alcohol and other respiratory depressants because of the danger of exacerbating hypoxemia during sleep. Symptomatic treatment, such as basic analgesics for headache and antiemetics, is often helpful. With conservative treatment, most patients successfully acclimatize over 24 to 48 hours and symptoms resolve.
- **Descent:** Descent is always effective treatment for AMS, but it is not mandatory or even necessary except in the setting of intractable, or progressing symptoms

- **Oxygen:** Supplemental oxygen effectively relieves the symptoms of AMS and can serve as an alternative to descent.
- **Hyperbaric therapy** : Portable, lightweight, manually inflated hyperbaric chambers are can be used to decrease symptoms of AMS. By increasing barometric pressure, hyperbaric bags are capable of simulating a descent of 2500 m or more, depending upon the altitude where they are used. One hour of treatment in a pressurized chamber relieves symptoms, although they may return within 12 hours.

Medications

- **Acetazolamide:** Treatment with acetazolamide, a carbonic anhydrase inhibitor, accelerates acclimatization to high altitude. Acetazolamide 250 mg BID may be prescribed for one to three days while the patient remains at the same altitude.
- **Dexamethasone** : Dexamethasone alleviates the symptoms of AMS, but does NOT improve acclimatization. Dexamethasone 4 mg taken orally or intramuscularly, q 6 hours, for one to two days can be prescribed alone, in lieu of acetazolamide, or in combination with acetazolamide. Further ascent while taking dexamethasone alone is not recommended because of the risk of symptoms recurring or worsening when the drug is stopped.