THE USE OF THERAPEUTIC GASES IN RESPIRATORY CARE

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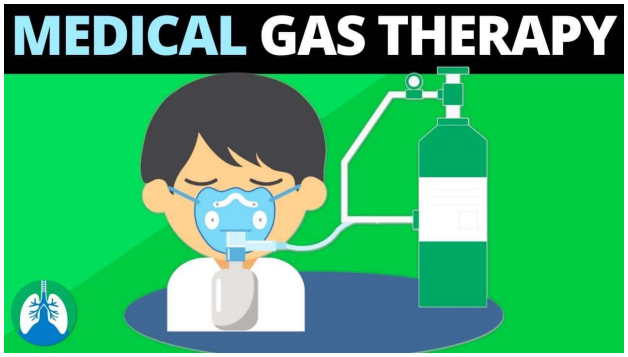
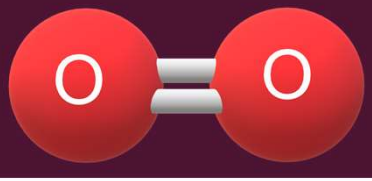
- Oxygen
- Nitric oxide
- Nitrous oxide
- Heliox
- CO2



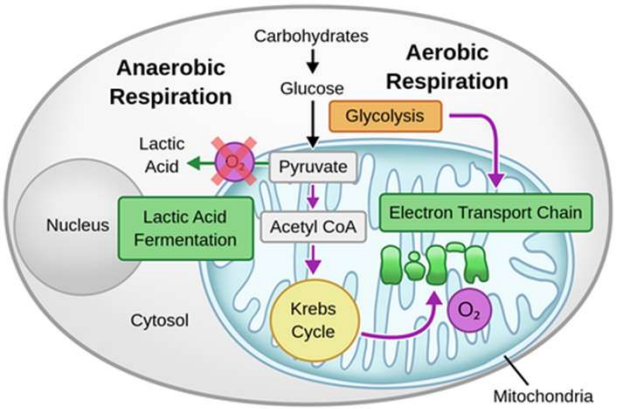
OXYGEN IS A DRUG

- Oxygen is the most common drug delivered by Respiratory Care
  - As with any drug, has indications and hazards.
  - Must be ordered by a physician
  - Clinical practice guidelines allow RT's to institute oxygen as needed in ***anticipation*** of a physician order

OXYGEN

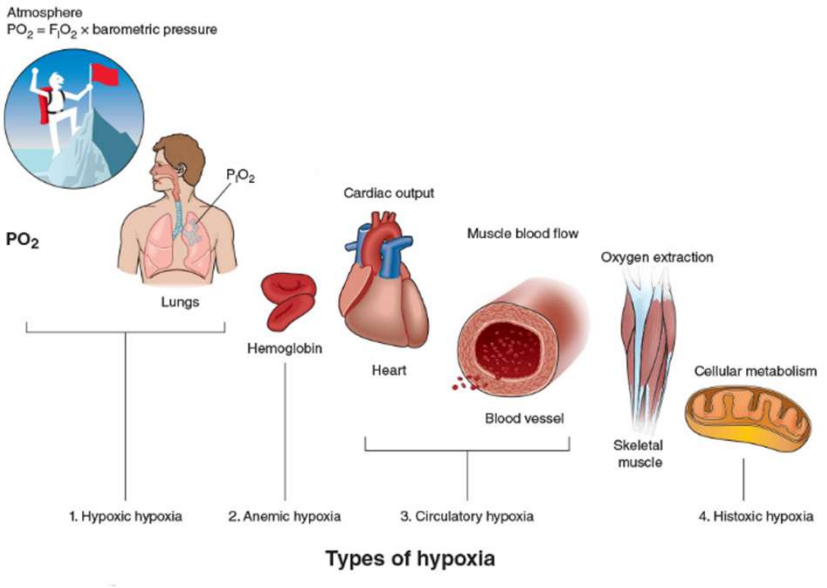


- Necessary for aerobic organisms
- Acts as the final electron acceptor in cellular respiration
- Oxygen availability to the cells is affected by numerous factors:
  - Blood flow as a function of Cardiac output
  - Blood oxygen carrying capacity as a function of Hb
  - V/Q matching in the lungs
  - Diffusion across the A/C membrane
  - Inspired percentage of oxygen



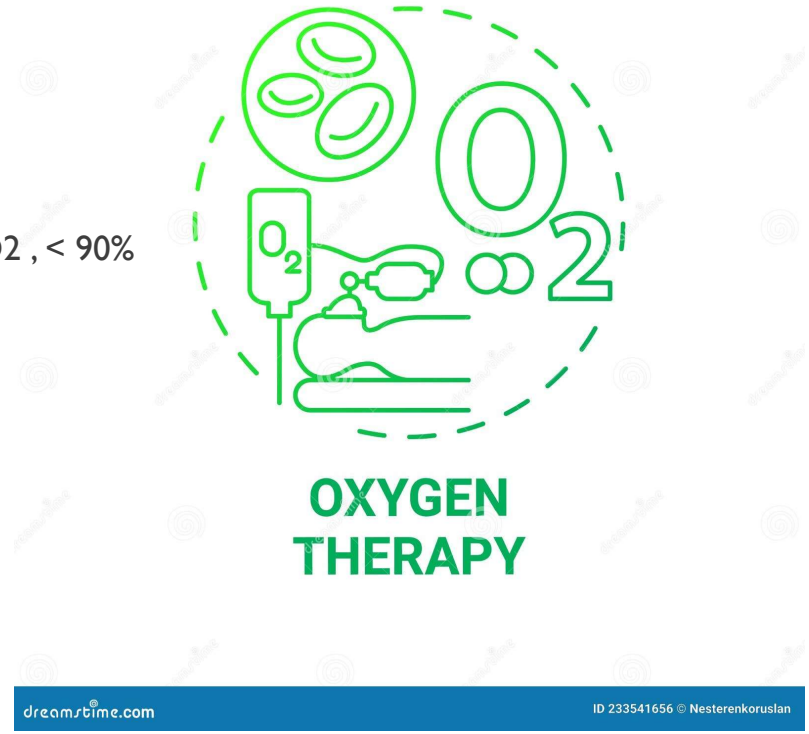
HYPOXIA

- Hypoxia – cells deprived of adequate levels of oxygen
  - Hypoxemia – the presence of inadequate levels of oxygen in the blood
    - Most common cause of hypoxemia is shunting, a form of V/Q mismatch
      - Shunting by definition is blood flow without gas exchange
        - Most common type of shunt is Intrapulmonary shunting – Blood flowing past under ventilated alveoli
          - Raising the inspired level of oxygen is an effective treatment for this type of hypoxemia

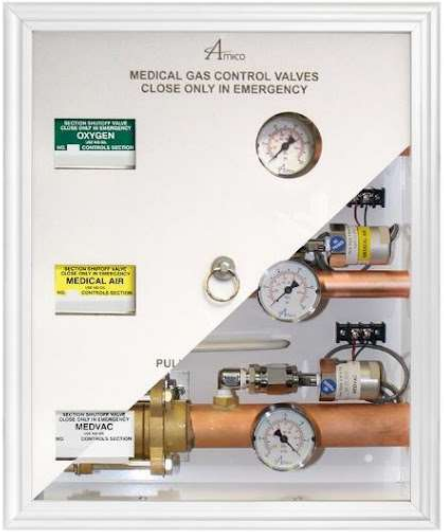


OXYGEN THERAPY

- The delivery of supplemental oxygen has three indications:
  - To treat hypoxemia, generally defined by a PaO2 < 60 mmHG, or SaO2 , < 90%
  - To decrease the work of breathing
  - To decrease the work of the heart.



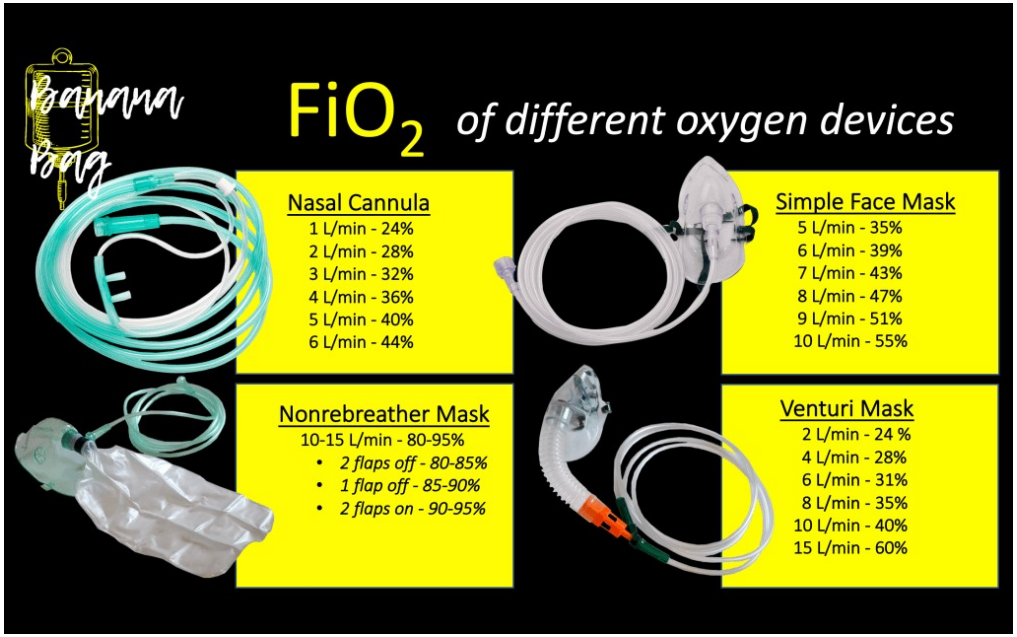
OXYGEN SOURCE



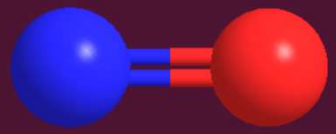
- Piped-in oxygen by a hospital's oxygen delivery system
  - Bulk liquid oxygen system supplies oxygen at 50 psi
  - The integrity of the system can be monitored in each zone of delivery by a measurement system
- Tanks:
  - H-Cylinder. Each PSI of pressure in this type of tank is about 3 liters of gas. (factor – 3.14)
  - E-Cylinder. Each PSI of pressure in this type of tank is about .3 liters of gas. (factor - .28)
    - Tank duration = $\frac{\text{(Tanks PSI) X (cylinder factor)}}{\text{Flow Rate}}$

OXYGEN DELIVERY DEVICES

- Low Flow devices: Nasal Cannula / Simple mask – a fixed flow of supplemental oxygen diluted/mixed with inspired air increasing the (unknown) FIO2
- High Flow devices: (any device that meets or exceeds the average inspiratory flow of 30 l/m and therefore no entrainment of an variable amount of room air)
  - Venti mask – limit 50%-60%
  - Aerosol Generator – if more than 60% required, may require two devices wye'd together to insure it's meeting at least 30 l/m
  - Vapotherm/Optiflow above 30 l/m
  - BiPaP
  - Ventilator

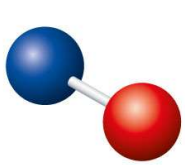


NITRIC OXIDE



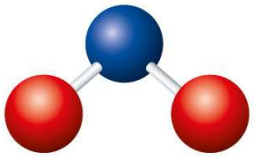
- Delivery is on the order of a physician
- Starting dose is 20ppm to a maximum of 80ppm
- Delivery is through a ventilator circuit or by nasal cannula

WHAT'S THE DIFFERENCE:



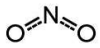
NO

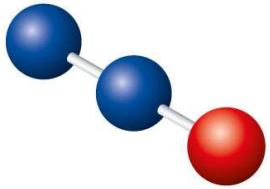
Nitric oxide



NO_2

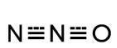
Nitrogen dioxide





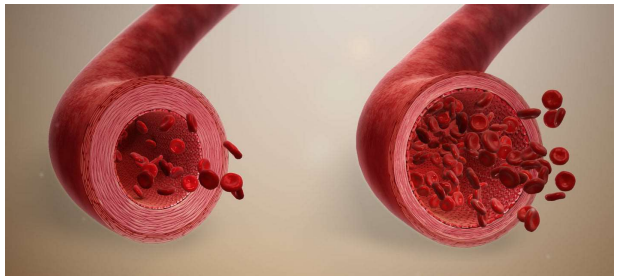
N_2O

Nitrous oxide

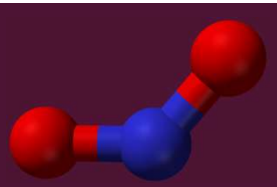


NITRIC OXIDE

- NO and Vasodilation Mechanism - NO diffuses into the smooth muscle cells of blood vessels and activates an enzyme called guanylate cyclase, which in turn increases the production of cyclicGMP (cGMP).
  - Elevated levels of cGMP cause the relaxation of smooth muscle cells, leading to vasodilation.
    - Vasodilation lowers Pulmonary Vascular Resistance which lowers the workload of the right heart
    - Enhanced perfusion of the pulmonary capillaries may optimize V/Q matching resulting in improved oxygenation.



HAZARDS OF NITRIC OXIDE



- Some NO may combine with Oxygen to produce nitrogen dioxide (NO_2)
  - NO_2 is a poisonous gas that may cause changes to Hb (Increases in METHb)
  - Available delivery systems monitor and minimize the production of NO_2
  - The Occupational Safety and Health Administration's safety limit for nitrogen dioxide is 5 ppm for 8 hours
  - Some devices will "shut down" delivery of NO if the percentage of NO_2 reaches 10%

EXPOSURE TO NO DURING PREGNANCY

- Although considered safe by many, data is lacking with respect to exposure to nitric oxide by pregnant women. Because of this, nitric oxide has been categorize into pregnancy risk group Category C medication. Meaning both pregnant patients and pregnant care givers should stay away from nitrous oxide
- Nitric oxide may benefit pregnant women with severe COVID-19

DELIVERY OF NO

- Delivery systems come in tank delivery or tankless. It's debatable which is more efficient and safer.

VS

NITROUS OXIDE

- Anesthetic gas
- Nitrous oxide is the least potent inhalational anesthetic.
- Nitrous oxide delivery systems must have a safety mechanism to prevent "nitrous only" delivery

HELIOX

- Helium is less dense than nitrogen so has a lower viscosity
- Commonly used in cases of fixed upper airway obstructions because heliox can enhance delivery of oxygen below the obstruction
- Also used in the treatment of status asthmaticus
- Comes in 80%/20% and 70%/30% concentrations

CLINICAL EFFECT OF HELIOX

- Heliox decreases WOB in patients with increased airway resistance.[59] However, heliox does not treat airway resistance, but, rather, reduces the inspiratory pressure of the patient or ventilator required for a given gas flow.
- Overall, the unique physical properties of helium promote less turbulent gas flow, decreased airway resistance, and decreased WOB in patients with air-flow obstruction.
- Because helium is an inert gas, not known to interact with human metabolism, it can be used on any patient without adverse effects.

DELIVERY OF HELIOX

- Oxygen flowmeter will read inaccurately with heliox. Actual flow is nearly two times the reading on the flow meter.
- 80%/20% - Actual flow is 1.8 times the reading on the flowmeter
- 70%/30% - Actual flow is 1.6 times the reading on the flowmeter

DELIVERY OF HELIOX

- NRB mask:
  - A flow meter reading of 15 L/m is actually delivering 27 L/m. This amount is close to supplying the **total*** needs of the adult patient.
  - For pedi patients: the total flow necessary is variable and is dependent upon the tidal volume. For example, if the patient has an expected tidal volume of 150ml, this translates to a flow rate of 12 l/m needed to meet total inspiratory demand. Therefore heliox could be run a 7 L/m to meet or exceed the 12 L/m
- High flow nasal cannula via optiflow
- Delivery of heliox with a low flow nasal cannula ***doesn't work.***

*30 L/m is the average inspiratory flow rate of the adult

OPTIFLOW DELIVERY OF HELIOX

Connect the Heliox regulator to the tank.

Set desired flow

Set desired fiO2 ($\leq$ 30)

Not intended for any other HFNC use

HFNC DELIVERY OF HELIOX

- How much? One strategy is to increase the flow until the patient's voice changes…when it does, you'll know you've reached the total flow needs of the patient.
- To conserve heliox, use the minimum flow needed. Remember the actual flow rate is nearly twice the reading on an oxygen flowmeter.

CO2

- Occasionally used in the treatment of congenital hypoplastic left heart syndrome.
- The percentage of CO_2 in room air is approximately 0.03% or 0.22 mm Hg
- The therapeutic range of delivered CO_2 is generally 1–4% or 8–30 mm Hg.

OTHER GASES

- Anesthetic gases such a sevoflurane can be used as a bronchodilator.