HYPOXIA AND OXYGEN THERAPY

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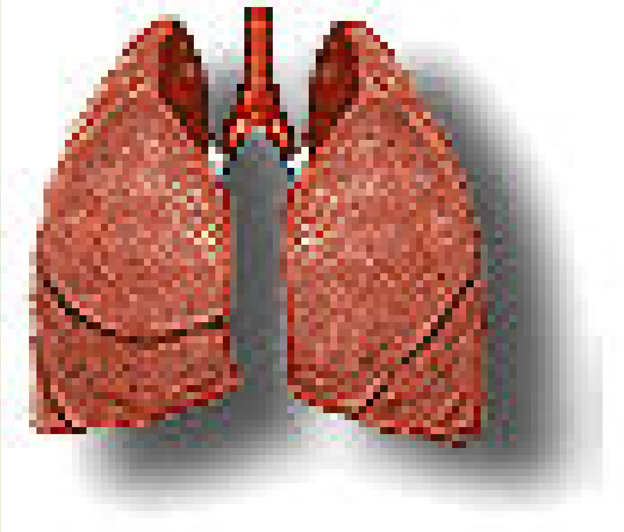
DIRECTOR ACADEMICS

Oxygen is necessary to any life .



- **Oxygen may be classified as an element, a gas, and a drug.**

Definition

- **Oxygen therapy** is the administration of oxygen at concentrations greater than that in room air to treat or prevent hypoxemia (not enough oxygen in the blood)

DEFINITION OF HYPOXIA

HYPOXIA MEANS

INADEQUATE O_2 SUPPLY TO THE BODY TISSUES

(ENTIRE BODY) OR (LOCALIZED REGION)

SYMPTOMS OF HYPOXIA

- DEPEND ON:

RAPIDITY AND SEVERITY

OF THE

DECREASE OF ARTERIAL Po2

1) **FULMINANT** hypoxia

(Arterial Po2<20mmHg)

(eg.aircraft loses cabin pressure above 30,000 feet and no supplemental O2 available)

Occurs in seconds → Unconsciousness in 15-20 sec

→ Brain death in 4-5 min

2) **ACUTE** hypoxia

(25mmHg<Arterial Po2<40mmHg)

(eg.altitudesof 18,000-25,000 feet)

Symptoms similar to those of ethyl alcohol(lack of coordination,slowed reflexes,overconfidence)

eventually →

Unconsciousness

Coma and death(in minutes to hours)

if the regulatory mechanisms of the body are inadequate

3) **CHRONIC** hypoxia

(40mmHg<Arterial Po2<60mmHg)

(eg.at altitudes of 10,000-18,000 feet for extended periods of time)

FOR EXTENDED PERIODS OF TIME!!!

Most clinical causes of hypoxia are in these category

Symptoms similar to those of <u>severe fatigue</u>

DYSPNEA

SHORTNESS OF BREATH

+

RESPIRATORY ARRHYTHMIAS

SIGNS OF HYPOXIA

1. **Cyanosis** (bluish color of tissue)

   caused by more than 5g of deoxyhemoglobin/dl in capillary blood(or less than 13ml O_2 per 100ml of blood)

NOT RELIABLE SIGN OF HYPOXIA!!!

→ **ANEMIC PATIENTS** never develop cyanosis but are extremely hypoxic

→ **PATIENTS WITH POLYCYTHEMIA** may be cyanotic but they are perfectly oxygenated

2. **Tachycardia**

   (peripheral chemoreceptor reflex response to Po2 ↓)

3. **Tachypnea and Hyperpnea**

   (arterial chemoreceptor reflex response to Po2 ↓)

TYPES OF HYPOXIA

ARTERIAL(HYPOXIC) HYPOXIA

RESULTS FROM:

INADEQUATE OXYGENATION OF THE ARTERIAL BLOOD

CAUSED BY:

1) **Breathing gas with Po2** ↓

2) **One or more pathophysiologic mechanisms:**

a) HYPOVENTILATION (not adequate alveolar ventilation)

alveolar and arterial Po2 ↓ ↑ alveolar and arterial Pco2

➡ *Hypercapnia*

b)DIFFUSION LIMITATION

(diffusion capacity of lungs decreased by a pulmonary disease)

c) PHYSIOLOGIC SHUNTS [VA/Q imbalance]

→ **most common cause of hypoxia**

d) ANATOMIC SHUNTS (mixing of venous and oxygenated(arterial)blood which dicreases the Po2)

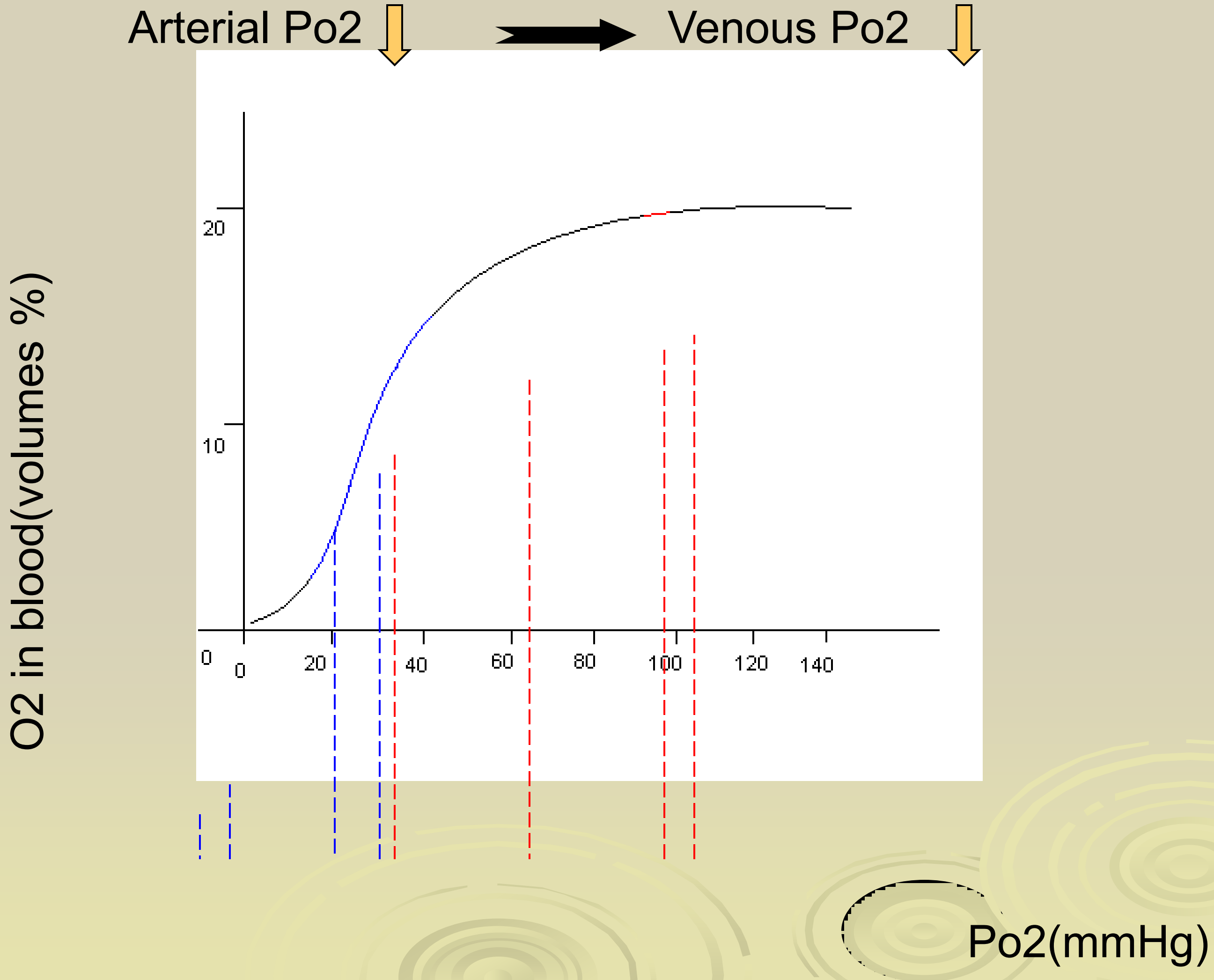
normally there is an anatomic shunt of about 3% of the cardiac output caused by the mixing of the oxygenated blood coming from the lungs with the venous blood of bronchial veins before entering the left atrium

↓

Pathologically is caused by **congenital cardiac malformations**

diagnosis: arterial Po2<500mmHg when breathing 100% O2

ARTERIAL(HYPOXIC)HYPOXIA



STAGNANT(ISCHEMIC) HYPOXIA

RESULTS FROM:

INADEQUATE BLOOD FLOW

entire body or localized area

caused by

Congestive heart failure *Arteriosclerosis*

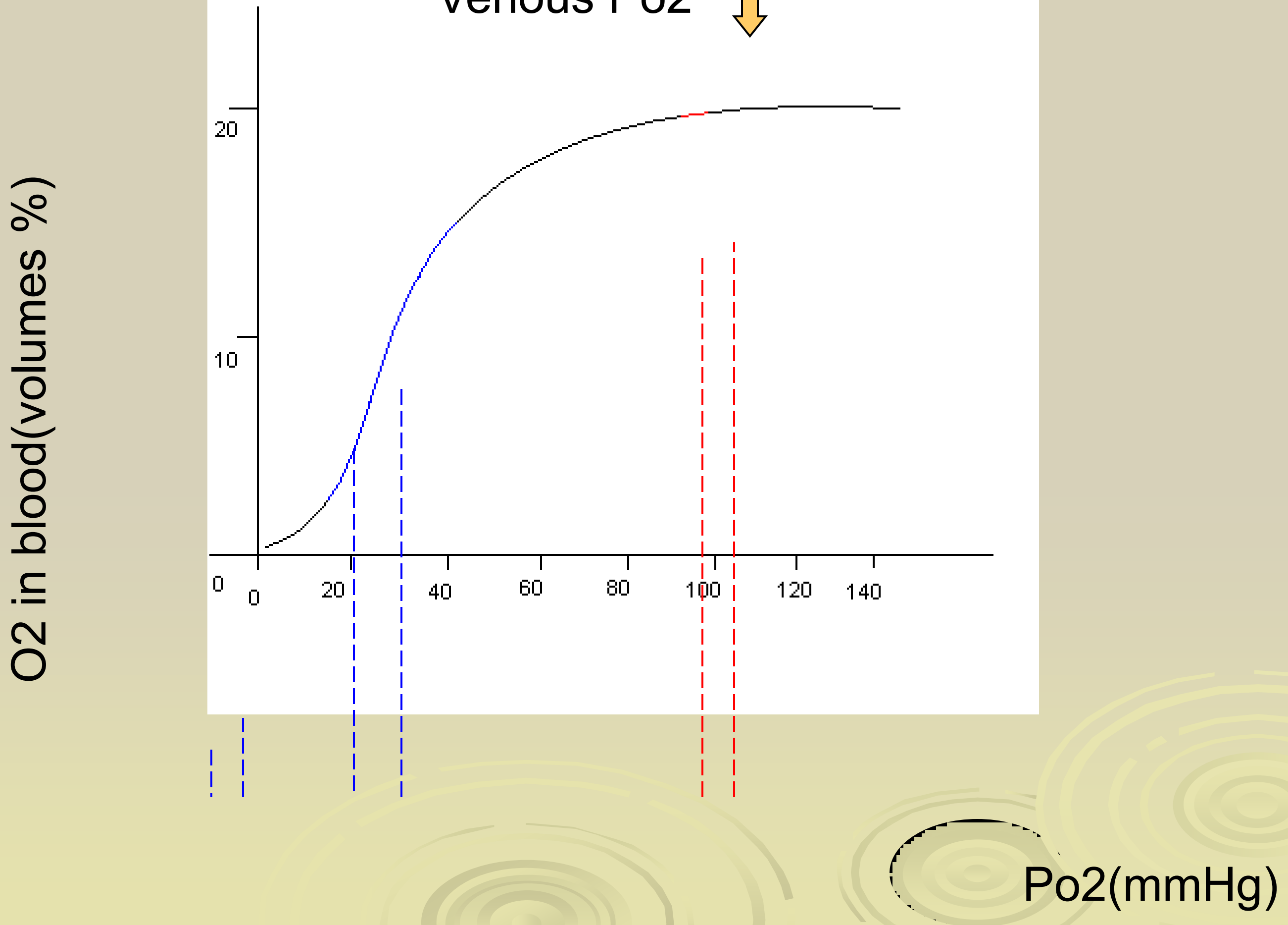
Arterial Po2 may be normal BUT because Q (blood flow),tissues withdraw larger amounts of O2 from the blood ,so, Venous Po2

STAGNANT(ISCHEMIC)HYPOXIA

Arterial Po2 ⟺

BUT

Venous Po2 ⇩



ANEMIC HYPOXIA

RESULTS FROM:

INSUFFICIENT AMOUNT OF FUNCTIONAL HEMOGLOBIN

CAUSED BY:

1) **Deficiency of essential nutrients(iron,B12 vitamin)**
2) **Blood loss**

Patients with Anemic hypoxia have reduced O2 capacity so they have reduced content of O2 in their blood

Arterial Po2is Normal but Venous Po2 ↓

OXYGEN FLUX

- O_2 flux
  = Amount of oxygen delivered to the peripheral tissues per minute.
- i.e. content delivered per minute
- NOT just content (which is a volume, not vol/min)
- **<u>Oxygen flux</u>**
- O_2 flux
  = O_2 bound to Hb + Dissolved O_2

Total oxygen flux

- Arterial O2 flux is
  = 5 x 150 x 0.98 x 1.34 + 5 x 100 x 0.03
  = 984.9 + 15
  = appr. **1000mL O2 per min**
- Assumes cardiac output of 5L/min
- Assumes [Hb] = 150g/L
- Assumes SaO2 = 98% and PO2 = 100mmHg
- pH 7.4, temp = 37

Oxygen Cascade

- **The oxygen cascade describes the process of declining oxygen tension from atmosphere to mitochondria.**

O_2 Cascade

Pasteur point – The critical level for aerobic metab. to continue (1 – 2 mmHg PO_2 in mitochondria)

Air

159 mm Hg

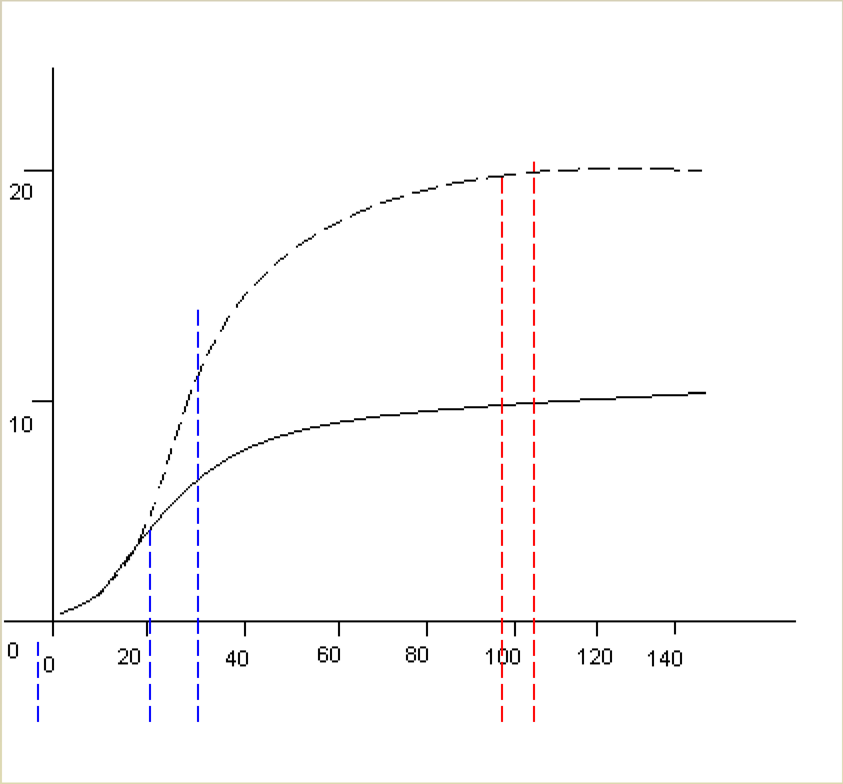
Mitochondria

4 mm Hg

Pasteur point – The critical level for aerobic metab. to continue (PO_2 1-2 mmHg in mitochondria, 22mmHg in capillary

ANEMIC HYPOXIA

Arterial Po2 ⟺ **BUT** Venous Po2 ⇩



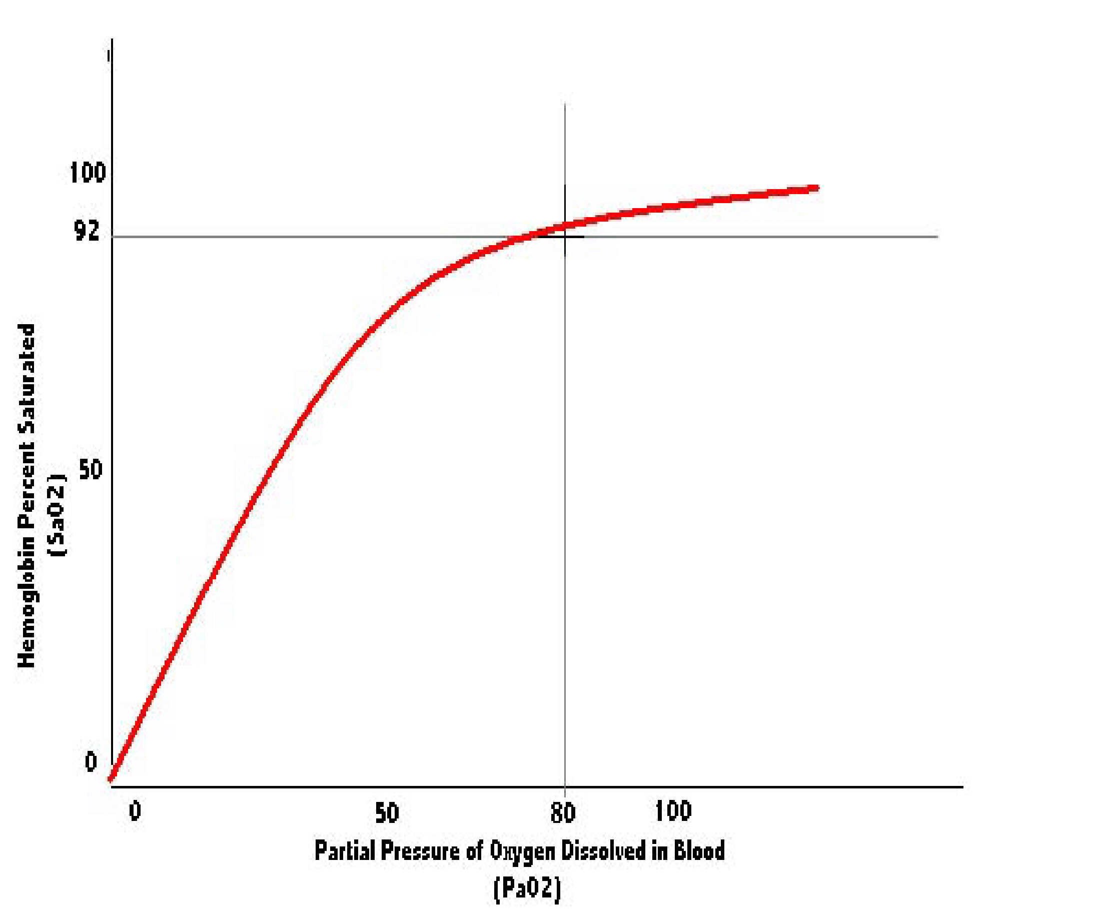
Purpose o2 therapy

- The body is constantly taking in O_2 & releasing CO_2. If this process is inadequate, oxygen levels in the blood decrease, and the patient may need supplemental oxygen. Oxygen therapy is a key treatment in respiratory care.
- The purpose is to increase oxygen saturation in tissues where the saturation levels are too low due to illness or injury.

Oxyhemoglobin Dissociation Curve

- Definition : A relationship between the amount of oxygen dissolved in the blood and the amount attached to the hemoglobin. This is called the normal Oxyhemoglobin dissociation curve.
- Oxygen can be measured in two forms:
  - partial atmospheric pressure of oxygen (PaO2)
  - oxygen saturation (SaO2)
  - calculated estimate of oxygen saturation (SpO2): an indirect SaO2

Normal Oxyhemoglobin Dissociation Curve

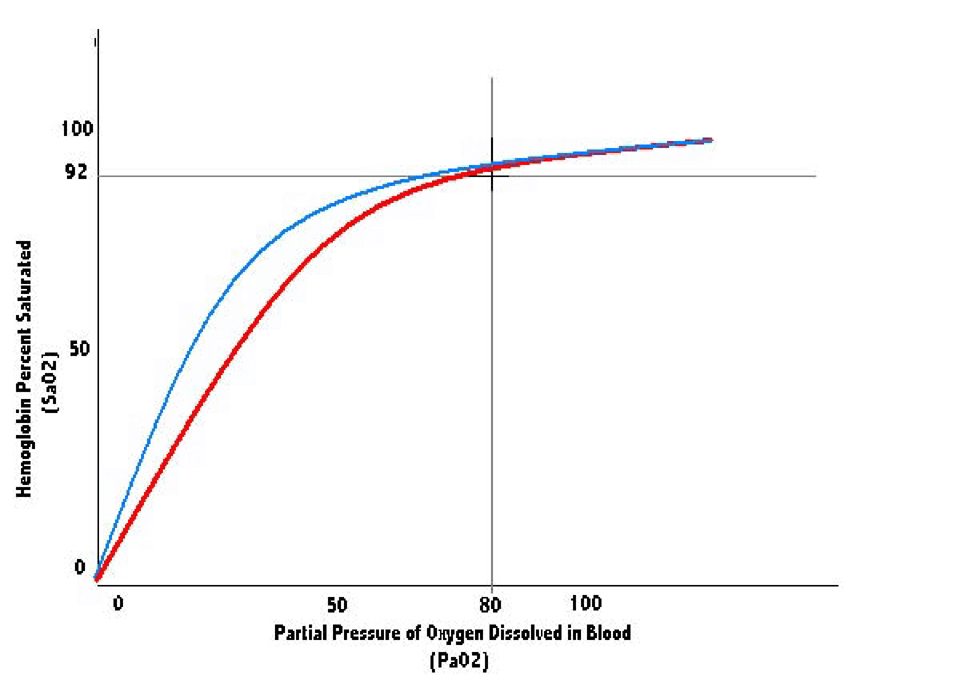


Predicted Relationship PaO_2 & SaO_2 Normal Oxyhemoglobin Dissociation Curve

PaO_2(mmHg)	SaO_2 (%)
100	98
90	97
80	95
70	93
60	89
50	84
40	75
30	57

97% saturation = 97 PaO2 (normal)
90% saturation = 60 PaO2 (danger)
80% saturation = 45 PaO2 (severe hypoxia)

Reference ranges	Arterial blood	Venous blood
pH	7.35 – 7.45	7.35 – 7.43
pCO2	35 – 45 mmHg	38 – 50 mmHg
pO2	80 – 100 mmHg	30 – 50 mmHg
HCO3-	22 - 26 mM	23 – 27mM
O2 saturation	95 – 100 %	60 – 85 %

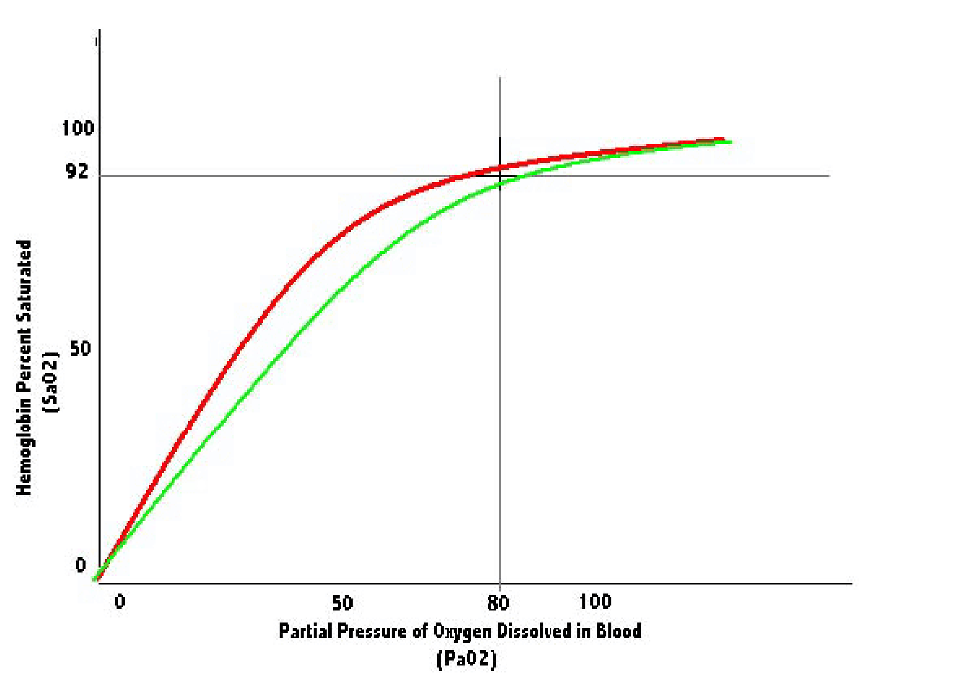


SHIFT TO LEFT

- Increase in pH
- Decrease in CO2
- Decrease in 2.3-DPG
- Decrease in temperature

SHIFT TO RIGHT

- Decrease in pH
- Increase in CO2
- Increase in 2,3-DPG
- Increase in temperature



Markers of O_2 monitoring

$PiO_2 = (760 - 47) \times 0.21 = 150$ mmHg

$FiO_2 = 0.21$

$PAO_2 = 100$ mmHg

$PaO_2 = 90$ mmHg

SaO_2 = O_2 saturation derived from arterialized cap. Blood.

SpO_2 = O_2 saturation by pulse. ox

Assessment of need

- Need is determined by measurement of inadequate oxygen tensions and/or saturations, by invasive or noninvasive methods, and/or the presence of clinical indicators as previously described.
  - Arterial blood gases
  - Pulse oximetry
  - Clinical presentation

How to assess oxygenation ?

- Arterial blood gases
- Pulse oximetry

<u>Errors in pulse oximetry</u>

- **Artificial fingernails**
- **Dark pigmentation**
- **Electrical**
- **Intravenous dyes**
- **Movement**

- **Nail Polish**
- **Pulsatile venous system**
- **Radiated light**
- **Edema**

Indications of O_2 therapy

1. Documented hypoxemia

In adults, children, and infants older than 28 days, arterial oxygen tension (PaO_2) of < 60 mmHg or arterial oxygen saturation (SaO_2) of < 90% in subjects breathing room air or with PaO_2 and/or SaO_2 below desirable range for specific clinical situation

In neonates, PaO_2 < 50 mmHg and/or SaO_2 < 88% or capillary oxygen tension (PcO_2) < 40 mmHg

2 . An acute care situation in which hypoxemia is suspected

Substantiation of hypoxemia is required within an appropriate period of time following initiation of therapy

3. Severe trauma
4. Acute myocardial infarction
5. Short-term therapy (e.g., post-anesthesia recovery)
6. Increased metabolic demands, i.e. burns, multiple injuries, and severe infections.

- Goal directed approach
  - post operative (thoracic/abdominal surgery)
  - post extubation
  - conscious state/coughing
  - redistribution of fluid
  - positioning

Three clinical goals of O_2 therapy

1. Treat hypoxemia

2. Decrease work of breathing (WOB)

3. Decrease myocardial Work

FACTORS THAT DETERMINE WHICH SYSTEM TO USE

1. Patient comfort / acceptance by the Pt
2. The level of FiO_2 that is needed
3. The requirement that the FiO_2 be controlled within a certain range
4. The level of humidification and /or nebulization
5. Minimal resistance to breathing
6. Efficient & economical use of oxygen

O_2 delivery methods

- Low flow oxygen delivery system
  (variable performance)

- High flow oxygen delivery system
  (fixed performance)

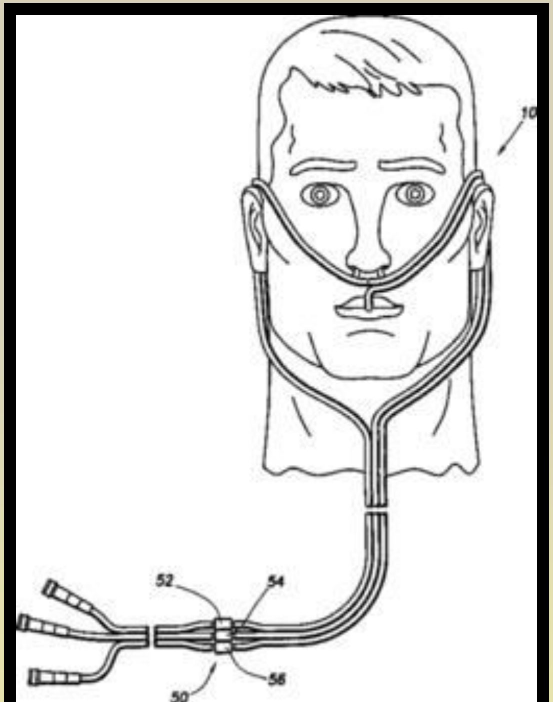
Low flow O_2 delivery system

Fio2 depends on O2 flow, patient factors and device factors

- Nasal cannula
- Simple face mask
- Partial rebreathing mask
- Non - rebreathing mask

Nasal cannula

- Simple plastic tubing + prongs
- Flow from 1-6 LPM of O_2
- FiO_2 ranges from 24-44% of O_2



1 - 24%

2 - 28%

3 - 32%

4 - 36%

5 - 40%

6 - 44%

- Correct placement
- No nasal obstruction

Advantages

- Inexpensive
- well tolerated, comfortable
- easy to eat, drink
- used in pt with COPD
- used with humidity

Disadvantages

Pressure sores

Crusting of secr.

Drying of mucosa

Epistaxis

Low flow O_2 delivery system

Fio2 depends on O2 flow, patient factors and device factors

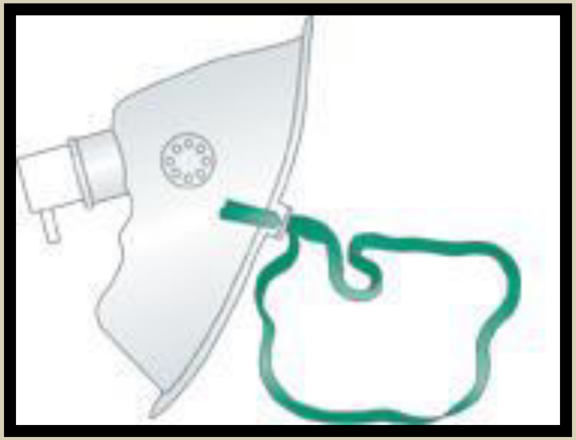
- Nasal cannula
- Simple face mask
- Partial rebreathing mask
- Non - rebreathing mask

Simple face mask

The placing of mask over the patient's face increases the size of the oxygen reservoir beyond the limits of the anatomic reservoir ;therefore a higher FiO2 can be delivered.

The oxygen flow must be run at a sufficient rate, usually 5 lpm or more to prevent rebreathing of exhaled gases.

- Advantages: simple, lightweight, FiO2 upto 0.60, can be used with humidity



- Disadvantages: need to remove when speak, eat, drink, vomiting, expectoration of secretions, drying / irritation of eyes, uncomfortable when facial burns / trauma application problem when RT in situ

Low flow O_2 delivery system

Fio2 depends on O2 flow, patient factors and device factors

- Nasal cannula
- Simple face mask
- Partial rebreathing mask
- Non - rebreathing mask

Partial rebreathing bag

- **Advantages:** FiO2 delivered >0.60 is delivered in mod. to severe hypoxia, exhaled oxygen from anatomic dead space is conserved.

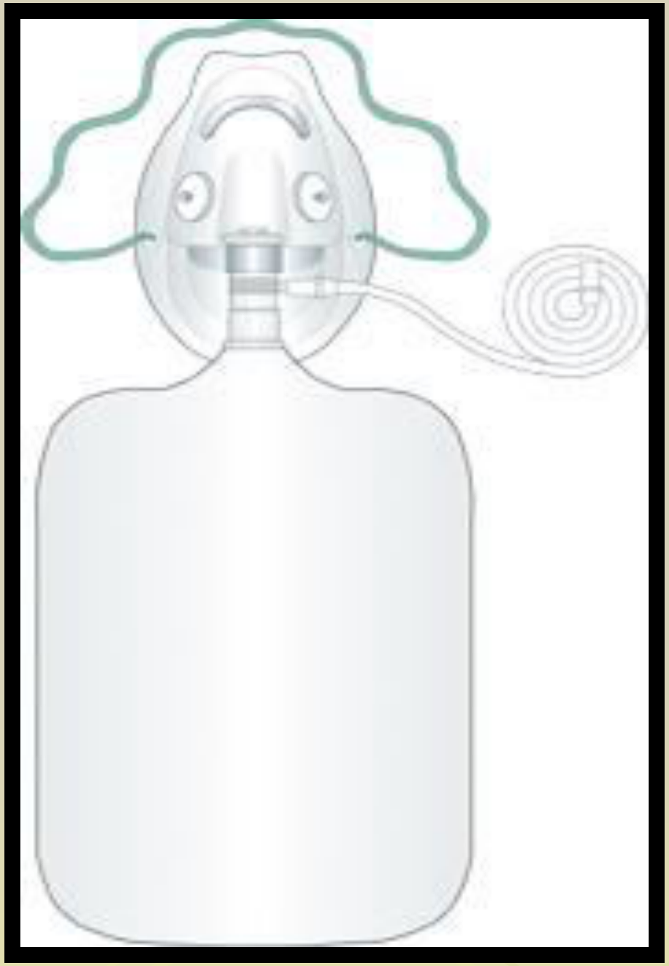
- **Disadvantages:** insufficient flow rate may lead to rebreathing of CO_2,claustrophobia;drying and irritation of eyes

Low flow O_2 delivery system

Fio2 depends on O2 flow, patient factors and device factors

- Nasal cannula
- Simple face mask
- Partial rebreathing mask
- Non - rebreathing mask

- **Non-rebreathing bag**



High flow O_2 delivery system

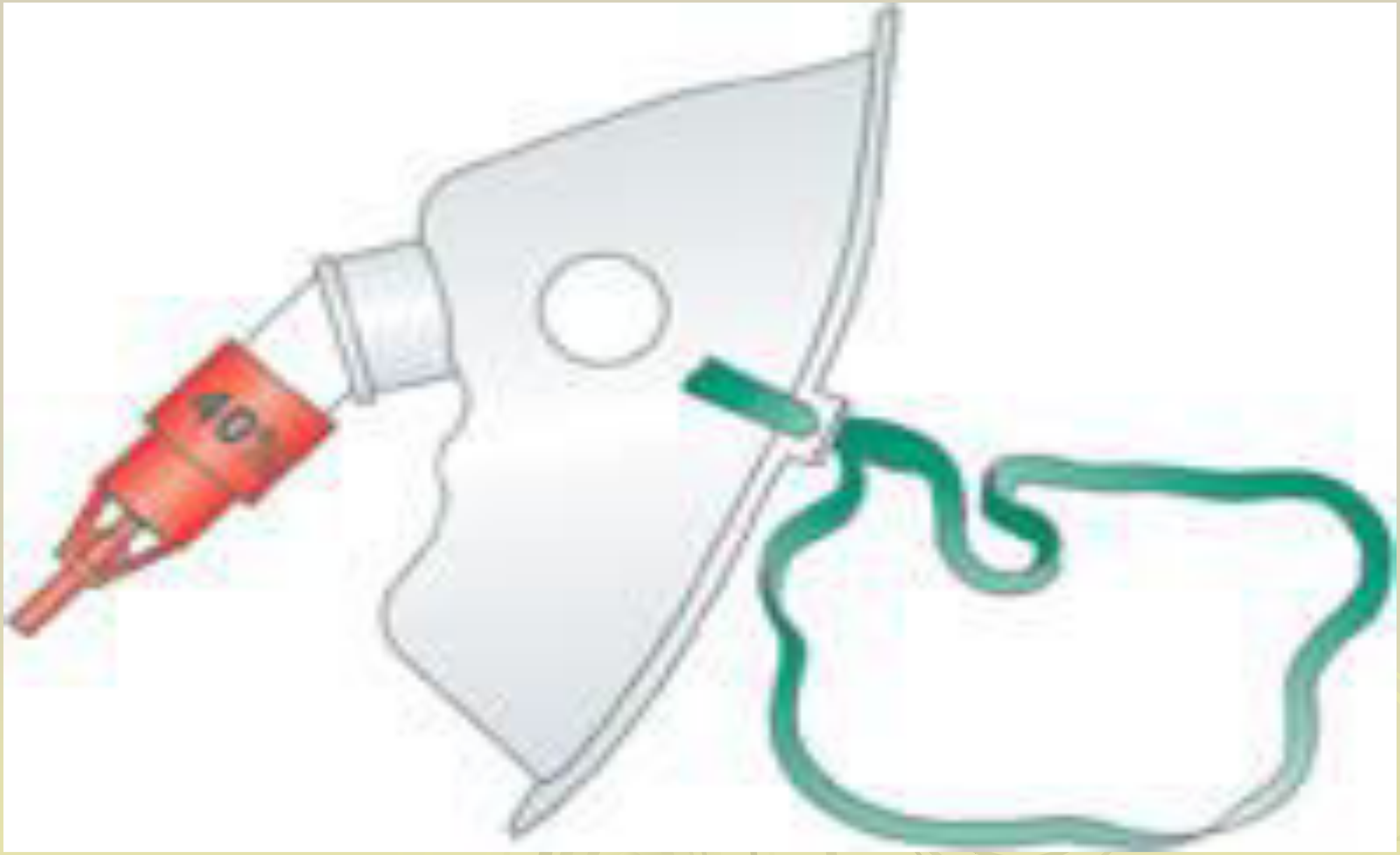
- Venturi mask
- Face tent
- Aerosol mask
- Tracheostomy collar
- T-piece

VENTURI VALVE

Venturi valve

Color	FiO2	O2 Flow
Blue	24%	2 L/min
White	28%	4 L/min
Orange	31%	6 L/min
Yellow	35%	8 L/min
Red	40%	10 L/min
Green	60%	15 L/min

Venturi mask




Face tent


Tracheostomy collar

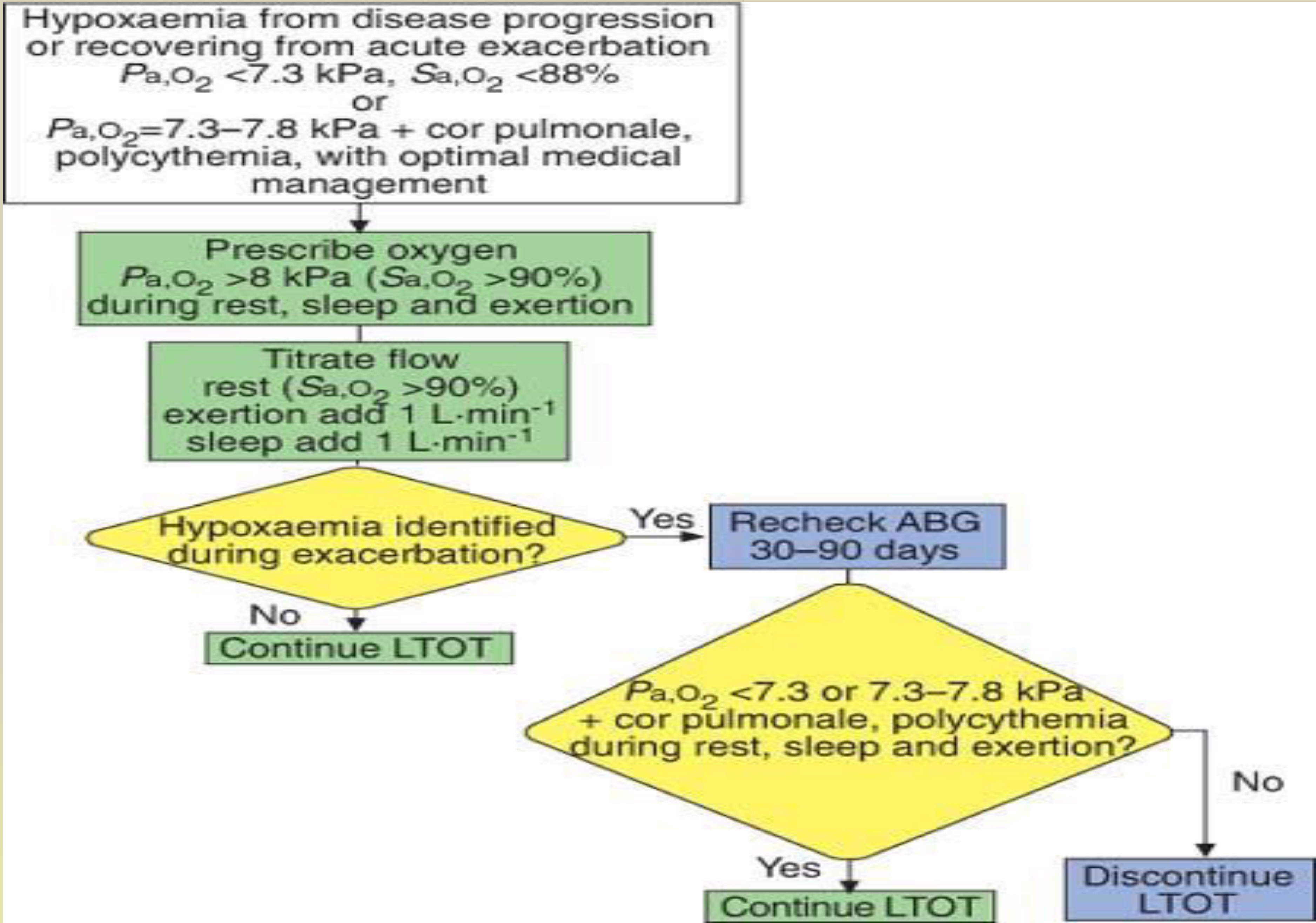
Pediatric oxygen delivery system

- **Oxygen hood**


Oxygen hood

Oxygen tent

Long-term oxygen therapy



- Long-term oxygen therapy (LTOT) improves survival, exercise, sleep and cognitive performance.
- Reversal of hypoxemia supersedes concerns about carbon dioxide (CO_2) retention.
- Arterial blood gas (ABG) is the preferred measure and includes acid-base information.
- Oxygen sources include gas, liquid and concentrator.
- Oxygen delivery methods include nasal continuous flow, pulse demand, reservoir cannulae and transtracheal catheter.

- Physiological indications for oxygen include an arterial oxygen tension (Pa,O_2) <7.3 kPa (55 mmHg). The therapeutic goal is to maintain Sa,O_2 >90% during rest, sleep and exertion.
- Active patients require portable oxygen.
- If oxygen was prescribed during an exacerbation, recheck ABGs after 30–90 days.
- Withdrawal of oxygen because of improved Pa,O_2 in patients with a documented need for oxygen may be detrimental.
- Patient education improves compliance

In-patient oxygen therapy-COPD

- The goal is to prevent tissue hypoxia by maintaining arterial oxygen saturation (Sa,O_2) at >90%.
- Main delivery devices include nasal cannula and Venturi mask.
- Alternative delivery devices include non-rebreathing mask, reservoir cannula, nasal cannula or transtracheal catheter.
- Arterial blood gases should be monitored for arterial oxygen tension (Pa,O_2), arterial carbon dioxide tension (Pa,CO_2) and pH.

- Arterial oxygen saturation as measured by pulse oximetry (*S*p,O_2) should be monitored for trending and adjusting oxygen settings.

- Prevention of tissue hypoxia supercedes CO_2 retention concerns.

- If CO_2 retention occurs, monitor for acidaemia.

- If acidaemia occurs, consider mechanical ventilation.

Monitoring oxygen therapy

Oxygen therapy should be given continuously.

The dose of oxygen should be calculated carefully.

Partial pressure of oxygen can be measured in the arterial blood.

Arterial PO2 of 60 mmHg can provide 90% saturation of arterial blood.

In a patient with respiratory failure, anaemia should be corrected for proper oxygen transport to the tissue.

A small increment in arterial oxygen tension results in a significant rise in the saturation of hemoglobin.

An increase of 1% oxygen concentration elevates oxygen tension by 7 mmHg.

Measurement of arterial blood gases repeatedly is difficult so a simple and non-invasive technique like pulse oximeter may be used to assess oxygen therapy.

When to stop oxygen therapy

Weaning should be considered when the patient is stabilized, BP, pulse rate, respiratory rate, skin color, and oxymetry are within normal range.

Weaning can be attempted by discontinuing oxygen or lowering its concentration for a fixed period for e.g., 30 min. and reevaluating the clinical parameters and SpO2 periodically.

Patients with chronic respiratory disease may require oxygen at lower concentrations for prolonged periods.

Hazards & complications of oxygen therapy

- Oxygen-induced hypoventilation
- Oxygen toxicity/O2 narcosis
- Absorption atelectasis
- Retinopathy
- Drying of mucous membranes
- Infection
- Fire hazards

Oxygen is one of the most important drugs you will ever use but it is poorly prescribed by medical staff.

In 2000, a Nicola Cooper and colleague did survey of treatment with oxygen.

The first looked at prescriptions of oxygen in postoperative patients in a large district hospital.

They found that there were many ways used to prescribe oxygen and that the prescriptions were rarely followed.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