Clinical Features of Hypoxia

Symptoms :

- Hypoxia of gradual onset :

- dyspnoea, drowsiness, headache, disorientation, anorexia
- nausea, vomiting

- Severe hypoxia onset :

- a sudden drop in inspired air of pO_2
- < 20 mm Hg : Loss of consciousness in 10-20 sec & death in 4-5 min

Signs

- Cyanosis [bluish discolouration of skin and mucous membranes caused by > 5g of deoxyHb / 100 ml of capillary blood].
- Tachycardia [as a result of peripheral chemoreceptor reflex response to low arterial O_2 tension].
- Tachypnoea [rapid breathing] - reflex response to hypoxia that are activated by peripheral chemoreceptors.

Effects of Hypoxia

1. Respiratory System
   - all types of hypoxia except ~~and~~ anemic hypoxia stimulates peripheral chemoreceptors to increase respiration.

2. CNS
   - drowsiness, impaired judgement
   - depression or excitement
   - headache
   - talkativeness, emotional outburst of laughing, shouting or crying

3. CVS
   - ~~cause~~ ↑ in Heart Rate
   - ↑ in BP
   - ↑ respiration.

4. Nausea, vomiting, anorexia
5. On alt: hypoxia inducible factors [HIF]

Treatment of Hypoxia

Oxygen Therapy

- Alveolar pO_2 can be ↑ed either by :-
  a. Inhalation of 100% pure O_2
  b. Inhalation of 100% pure O_2 at high barometric pressure, called hyperbaric O_2 therapy.

* Methods

1) Oxygen Tent
2) Oxygen Mask
3) Mechanical ventilator
4) Intranasal tube

O_2 Therapy in different forms of Hypoxia

- In hypoxic hypoxia - ↑es arterial PO_2
- In anemic hypoxia - ↑es quantity of dissolved O_2 in plasma
- Stagnant hypoxia - not useful
- Histotoxic hypoxia - not useful.

Hyperbaric Oxygen Therapy

- Administration of 100% oxygen at high barometric pressure (3 atm P)
- Main aim : to ↑ the O_2 transport in the dissolved form in the plasma
- This is the most common cause for O_2 toxicity
- Normal dissolved O_2 in plasma is 0.003/100 ml / mm Hg PO_2

Indication

- CO poisoning (anemic hypoxia)
- Gas gangrene
- ~~Decompression~~ Decompression sickness
- Air embolism
- Histotoxic hypoxia

HYPOXIA

Definition :- Deficiency of O_2 at tissue level.

- Tissue suffer from hypoxia :-
  1) when adequate O_2 supply ↓
  2) failure of utilizing available O_2

Types of Hypoxia

- Hypoxic hypoxia
- Anemic hypoxia
- Stagnant hypoxia
- Histotoxic hypoxia

1) Hypoxic Hypoxia

- PO_2 of the arterial blood ↓s.
- O_2 CC of blood is normal
- Low arterial O_2 content
- Low arterial % saturation of Hb.
- Low A-V pO_2 difference.

Causes

1. Low PO_2 in inspired air
   a. At high altitude
   b. Breathing gas mixture at low pO_2
2. Hypoventilation / Decreased alveolar ventilation
   a. Obstruction of resp. passages in bronchial asthma.
   b. Paralysis of resp. muscles in - poliomyelitis
   c. Respiratory centre depression - by drugs like morphine
   d. Kyphosis and scoliosis.
3. Diffusion defects
   a. Marked reduction in area of resp. memb.
   b. Increased thickness of resp memb.
4. Venous arterial shunts

→ venous blood enters arterial blood without going into the lungs
eg:- cyanotic congenital heart disease
→ therefore, arterial pO_2 decreases

3) STAGNANT / ISCHAEMIC HYPOXIA

• Blood flow to tissues is so low / slow that adequate oxygen is not delivered to them despite normal arterial pO_2 & Hb.

- Normal arterial pO_2
- Normal arterial O_2 content
- Arterial Hb content - normal
- Normal arterial % saturation of Hb.
- A-V pO_2 difference - more than normal.

Causes

1) Generalised
   - congestive cardiac failure
   - shock
2) Localised
   - atherosclerosis
   - thrombosis
   - embolism

4) HISTOTOXIC HYPOXIA

- Due to ↓ed ability of tissues to utilize O_2.
- Arterial pO_2 is normal.
- Arterial O_2 content - normal
- Arterial Hb content - normal
- Normal arterial % saturation of Hb
- A-V pO_2 difference - less than normal.

Causes

1) cyanide poisoning
2) sulfide poisoning
3) Vitamin B deficiency / Beri beri

Pathophysiology

cyanide poisoning & sulfide poisoning

↓

destroy cellular oxidative enzymes & paralyze the cytochrome oxidative system

↓

effects tissue oxidation

- When CO combines with Hb.
  (i) the amt of Hb to combine with O_2 is reduced
  (ii) Moreover, COHb releases CO slowly
- CO has 200 times more affinity than O_2.
- ODC shifts to left decreasing the amt of O_2 to be released.

Signs and Symptoms of CO poisoning

- Headache, nausea, loss of consciousness
- Cherry red discolouration of skin, mucous membr and nail bed.
- Progressive brain damage, mental changes

Treatment of CO poisoning

- Hyperbaric oxygenation : increases the dissociation of Hb

Pathophysiology of Anemic Hypoxia

⇒ In anemic hypoxia, at rest hypoxia is not severe

Hypoxia
↓
2,3-DPG in RBC ↑s
↓
2,3-DPG combines with oxy Hb [HbO_2]
↓
increased dilleration of O_2

⇒ In anemic hypoxia, in exercise
There is ↑ed O_2 demand by tissues
↓
so ↑ed O_2 consumption
↓
tissue demand is not fully met
↓
severe hypoxia

Effects of 100% oxygen therapy : oxygen toxicity

1. For > 8 hrs, it stimulates irritant receptors in the resp passages
- Nasal congestion, sore throat, sneezing, coughing, tachypnoea with bronchoconstriction.

2. For > 24 hrs : bronchopneumonia
- decrease in surfactant synthesis
- inhibiting ability of lung macrophages to kill bacteria.

- Newborn infants are very sensitive to O_2 toxicity.
- They should never be given > 40% O_2 inhalations as it can lead to :-
  a. proliferation of retinal vessels with formation of fibrous tissues (retrolental fibroplasia) - permanent blindness.
  b. Formation of lung cyst & densities (bronchopulmonary dysplasia)

3. CNS effects
- Nausea, irritability, dizziness, disorientation, muscle twitching, convulsions, coma and even death.
- Tinnitus, loss of eqm, blurred vision etc.

* Oxidative damage can occur in any cell in the body.

Mechanism of O_2 toxicity

Inhalation of 100% O_2

↓

- Conversion of molecular O_2 to oxidizing free radicals like superoxide anion [O_2^-] and hydrogen peroxide (H_2O_2)

↓

They oxidise PUFA (essential compounds of all membr) and destroy cellular enzymes (damaging cellular metabolic systems).

↓

Toxic effects

Pathophysiology of Hypoxic Hypoxia

Hypoxic hypoxia
↓ via Peripheral chemoreceptors
Stimulate respiratory centre
↓
Pulmonary ventilation increases
↓
CO_2 wash out from the body
↓
Arterial pCO_2 decreases
↓
oxygen – Hb curve shifts bt to left
↓
Less release of O_2 from Hb
↓
Tissue hypoxia

2) ANEMIC HYPOXIA

- Arterial pO_2 is normal but amt of Hb available to carry oxygen is reduced.
- Due to decreased CC of blood
- pO_2 → normal
- arterial O_2 content → ~~normal~~ low
- arterial % of H saturation of Hb → low
- A–V pO_2 difference → normal

Causes
- Anemia
- Altered Hb (i) met Hb [Fe^{3+} instead of Fe^{2+}]
  (ii) carboxy Hb [as CO poisoning]

CO poisoning
- CO is toxic and it combines with Hb to form carboxyhemoglobin or carboxy Hb [COHb]