Oxygen Therapy
Acute Oxygen Therapy

A life saving drug, very often given without careful evaluation of its potential benefits and side effects.

Like any drug there are clear indications for treatment with oxygen and appropriate methods of delivery.
Acute Oxygen Therapy

Inappropriate dose and failure to monitor treatment can have serious consequences.

Vigilant monitoring to detect and correct adverse effects swiftly is essential.
Acute Oxygen Therapy

- 21% of prescriptions inappropriate and 85% patients inadequately supervised (BMJ 1998; 317: 798-801)

Safe and effective treatment prescriptions should cover:

- the flow rate
- delivery system
- duration
- monitoring of treatment
PathophysiologicaPathophysiologica

tissue hypoxia

Arterial hypoxaemia

- Low inspired oxygen partial pressure (high altitude)
- Alveolar hypoventilation (sleep apnoea, opiate overdose)
- Ventilation-perfusion mismatch (acute asthma, atelectatic lung zones, parenchymal diseases)
- Right-to-left shunts
Pathophysiological mechanisms of tissue hypoxia

Failure of oxygen transport system
- Inadequate tissue perfusion
- Low haemoglobin concentration
- Abnormal oxygen dissociation curve (haemoglobinopathies, high carboxyhaemoglobin)
- Histotoxic poisoning of intracellular enzymes (cyanide poisoning, septicaemia)
Recognition of hypoxaemia

Successful treatment of tissue hypoxia requires early recognition.

This can be difficult because the clinical features are often non-specific.
Recognition of hypoxaemia

- Altered mental state
- Dyspnoea
- Cyanosis
- Tachypnoea
- Arrhythmias
- Coma
Recognition of hypoxaemia

- Hyperventilation due to carotid chemoreceptor stimulation is pronounced when $\text{PaO}_2 < 5.3$ kPa.
- Peripheral vasodilation with consequent systemic hypotension and eventually coma occurs if the $\text{PaO}_2 < 4$ kPa.
- Central cyanosis is an unreliable indicator of tissue hypoxia.
Measuring Oxygenation

- Initiation, monitoring and adjustment of oxygen therapy should be guided by Arterial Blood Gas analysis.
- Pulse oximetry is a most useful tool.
- \( \text{PaO}_2 \)
- \( \text{SaO}_2 \)
- \( \text{CaO}_2 \)
- \( \text{P}_v\text{O}_2 \) (tissue hypoxia)
Goals of Oxygen Therapy

- Treat hypoxaemia
- Decrease work of breathing
- Decreased myocardial work
Indications for acute therapy

- Cardiac and respiratory arrest
- Hypoxaemia (PaO$_2$ < 7.8 kPa, SaO$_2$ < 90%)
- Hypotension (systolic blood pressure < 100 mm Hg)
- Low cardiac output and metabolic acidosis (bicarbonate < 18 mmol/l)
- Respiratory distress (respiratory rate > 24/min)
Methods of delivering oxygen

Determined by:

- Degree of hypoxaemia
- Required precision
- Comfort of the patient
- Cost
- Availability
FiO$_2$

- The standard way to express the inspired oxygen concentrations
- Alveolar measurements are complex and impractical
- Tracheal measurements are invasive

FiO$_2$ = Volume of 100% O$_2$ / V$_T$
Uptake and distribution

Uptake depends upon:

- $\text{FiO}_2$
- $\text{V/Q relationships}$
- $P_{\text{O}_2}$

Distributed to all perfused tissues, from ECF to ICF
Systems for Oxygenation

Rebreathing systems
- Have a CO$_2$ absorber
- Used in anaesthesia

Non-rebreathing systems
- Low flow (variable performance)
- High flow (fixed performance)
Non-rebreathing systems

Preferred because:

- Oxygen is cheap
- Non-explosive
- Rebreathing of $\text{CO}_2$ is easily avoided
Low flow systems

\[ \text{FiO}_2 \text{ depends upon:} \]
- Size of available oxygen reservoir
- Flow rate
- Breathing pattern \((V_T \text{ and RR})\)

Low flow does not mean low \(\text{FiO}_2\)
Low flow systems (cannula)

- $V_T = 500 \text{ mL}$
- RR = 20/min
- Inspiratory time = 1s
- Expiratory time = 2s
- Anatomic reservoir = 50 mL
- $O_2$ at flow of 6L/min (100mL/s)

- Last 25% of exp allows reservoir to fill with 100% $O_2$ (50ml)
- 1 s insp gives 100mL 100% $O_2$
- Remaining 350 ml is room air (20% $O_2$) i.e 70ml 100% $O_2$
Low flow systems (cannula)

- Total 100% $O_2 = 50 + 100 + 70 = 220$ in 500 ml of tidal volume
- Thus $FiO_2 = 220/500 = 0.44$
- For every 1 L/s increase in flow, $FiO_2$ increases by 4%
- Thus, $FiO_2$ will be 24 - 28 - 32 - 36 - 40 - 44 at flows from 1 to 6 L/min
Low flow systems (cannula)

Total 100% O$_2$ = 50 + 100 + 70 = 220 in 500 ml of tidal volume

If $V_T = 250$, total 100% O$_2$ is:
50 + 100 + 20 = 170

Thus FiO$_2$ = 170/250 = 0.68

Lower $V_T$ and faster RR - FiO$_2$
Low flow system (cannula)

- Convenient
- Cheap
- Easily available
- Does not interfere with eating and talking
- Local irritation and dermatitis after long term use
Low flow systems

Effect of increasing reservoir

Use a mask

- Keep flow at 5 LPM or more
- Max flow = 8 LPM
- $\text{FiO}_2$ upto 60% can be given
High Flow Systems

High flow systems deliver about 40 l/min of gas through the mask, which is usually sufficient to meet the total respiratory demand.

This ensures that the breathing pattern will not affect the FiO₂.

The masks contain venturi valves, which use the principle of jet mixing (Bernoulli effect).
High Flow Systems

Air entrainment depends on:
- velocity of the jet (the size of orifice and oxygen flow rate)
- size of the valve ports

It can be accurately controlled to give inspired oxygen levels of 24-60%.
Monitoring oxygen therapy

Arterial blood gas analysis should be performed before oxygen therapy if possible.

Arterial blood gases should be measured or oximetry done within 2 hours of starting oxygen therapy and $\text{FiO}_2$ adjusted accordingly (An adequate response is defined as $\text{PaO}_2 > 7.8 \text{ kPa}$ or $\text{SaO}_2 > 90\%$)
Monitoring oxygen therapy

- Hypoxaemic patients at risk of arrhythmias or respiratory failure should be monitored continuously by oximetry.

- In patients at risk of type II respiratory failure, arterial blood gases should be measured more frequently to assess PaO$_2$ and SaO$_2$ should be monitored continuously by oximetry.
Stopping oxygen treatment

Oxygen should be stopped when arterial oxygenation is adequate with the patient breathing room air ($\text{PaO}_2 > 8 \text{kPa}, \text{SaO}_2 > 90\%$).

In patients without arterial hypoxaemia but at risk of tissue hypoxia, oxygen should be stopped when the acid-base state and clinical assessment of vital organ function are consistent with resolution of tissue hypoxia.
Adverse effects

- Retinopathy in premature infants
- Absorption atelectasis
- Depression of ciliary activity
- Altered surfactant production
- Fire hazard
Refractory hypoxaemia

Failure of arterial oxygen to show an adequate response to increased $\text{FiO}_2$

Occurs due to Zero V/Q (true shunts)

Important to recognize because:

😊 Compensatory response is increased Cardiac output and hence increased myocardial work

😊 Excessive $\text{FiO}_2$ may be harmful
Refractory hypoxaemia

- Recognized by oxygen challenge
- An increase in FiO$_2$ of 0.2 increases PaO$_2$ by at least 10 mm
- Shunts greater than 30% will fail an oxygen challenge
Refractory hypoxaemia

\[ \text{PaO}_2 < 60 \text{ at FiO}_2 > 0.35 \]

OR

\[ \text{PaO}_2 < 60 \text{ at FiO}_2 < 0.35 \text{ and response to oxygen challenge is } <10 \text{ mm} \]

**Causes**

**Cardiovascular**
- Pul AV fistula
- Rt to Lt intracardiac shunts

**Pulmonary**
- ARDS
- Large pneumonia
- Collapse
- Mass
Long term Oxygen Therapy

Advanced lung diseases leads to permanent failure to maintain normal oxygenation

- COPD
- ILD
- Cystic fibrosis
- Bronchiectasis
Long term Oxygen Therapy

- End result is Pulmonary Artery Hypertension

- This leads to RVH and eventually RVF (Cor Pulmonale)

- Oxygen is the only drug that is known to retard the progress of PAH
Long term Oxygen Therapy

Indications

- $\text{PaO}_2 < 55 \text{ mm Hg}$
- $\text{PaO}_2$ 55-59 mmHg with evidence of cor pulmonale, polycythemia

Patient should be stable and ABG should have been done twice at an interval of 4 weeks
Domiciliary oxygen

- Compressed oxygen cylinders
- Oxygen concentrators
- Portable liquid oxygen cylinders
Compressed oxygen cylinders

**Advantages**
- Easily available
- Short-term economy
- No power requirement

**Disadvantages**
- Long term costs are high
- Frequent refills
- Fire hazard
- Heavy
Oxygen concentrators

**Advantages**
- Economical in the long run
- Permanent source
- No need for refills

**Disadvantages**
- High short-term costs
- Power required
- Require servicing, spares
Portable liquid oxygen cylinders

Advantages
- Small and portable
- No need for power

Disadvantages
- Refills required
- High cost
- Not available widely
Summary

- Oxygen is a life-saving drug
- Should be used when clear indications are there
- Flow rates, devices, duration must be specified
- Oxygen therapy must be monitored properly