Respiratory infection
&
Oxygen therapy for children

Dr Zeinab Hemati, Assistant Professor of Nursing Education, Isfahan University of Medical Sciences

Background

- Every year, over 5.9 million children die, mostly from preventable or easily treatable diseases, and more than 95% of those deaths occur in developing countries.
- Pneumonia is the leading cause of death in children under 5 years of age.
- estimated 120 million episodes of pneumonia in children under 5 years (14 million progressed to severe disease and 1.3 million led to death).
- 23% of the 5.9 million annual child deaths result from neonatal conditions spatially birth asphyxia

Background

- Hypoxaemia is the major fatal complication of pneumonia, increasing the risk for death many times.

- It is estimated that at least 13.3% of children with pneumonia have hypoxaemia.

Background

Despite its importance, hypoxaemia is often not well recognized or managed in settings where resources are limited.

- oxygen treatment remains an inaccessible luxury for a large proportion of severely ill children admitted to hospitals in developing countries.

- if some facility for delivering oxygen is available; poorly maintained, inappropriate equipment, poorly trained staff, inadequate guidelines.

Background

- Health workers should know the clinical signs that suggest the presence of hypoxaemia.

More reliable detection of hypoxaemia; pulse-oximetry, which is a non-invasive measure of arterial oxygen saturation.

Several conditions must be met for hypoxaemic children is necessary to save their lives;

- child must be recognized as hypoxaemic; clinical signs or pulse-oximeter
- receive adequate, uninterrupted oxygen therapy for an adequate duration.

Hypoxaemia and hypoxia

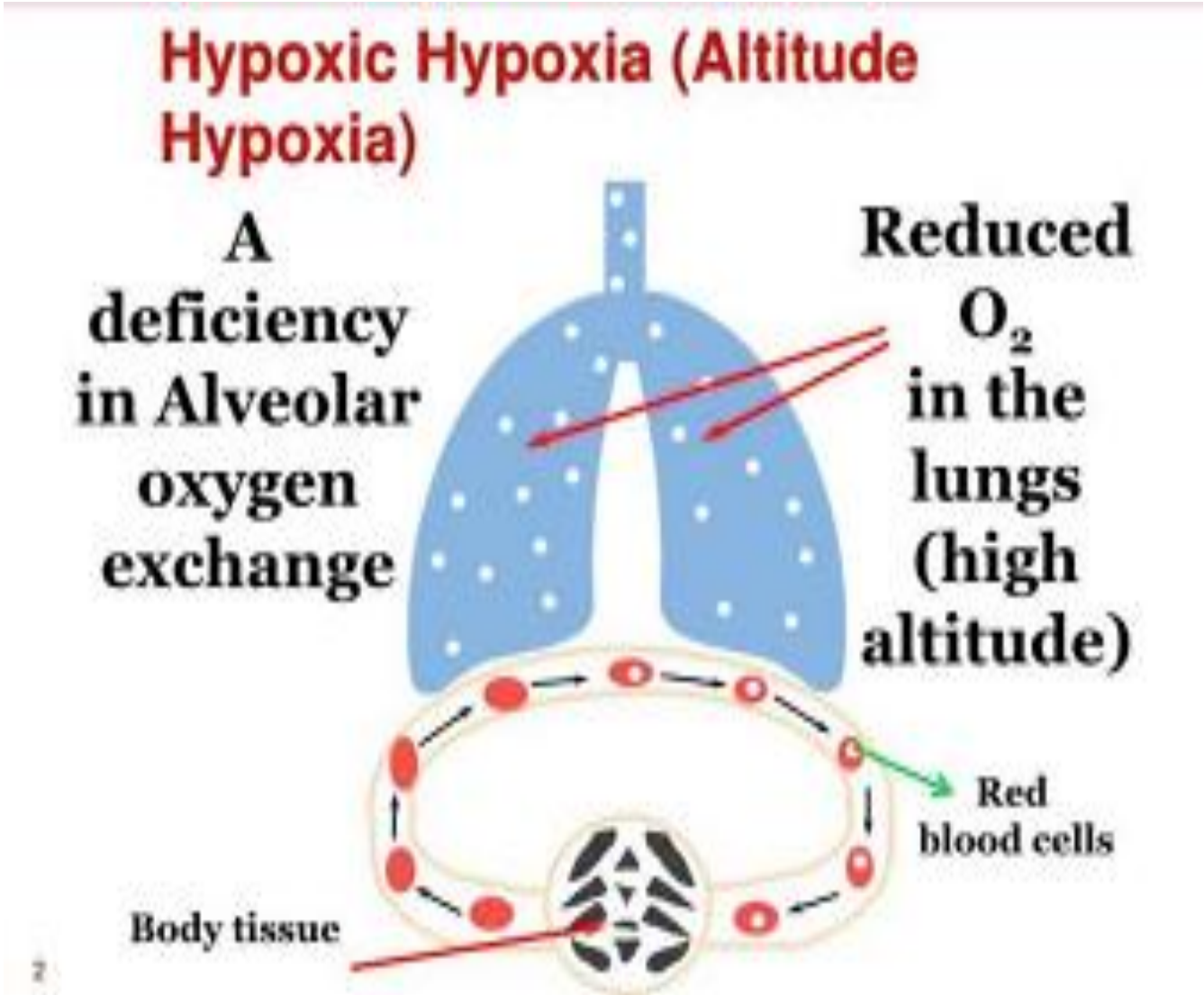
- Hypoxaemia; low levels of oxygen in the blood.

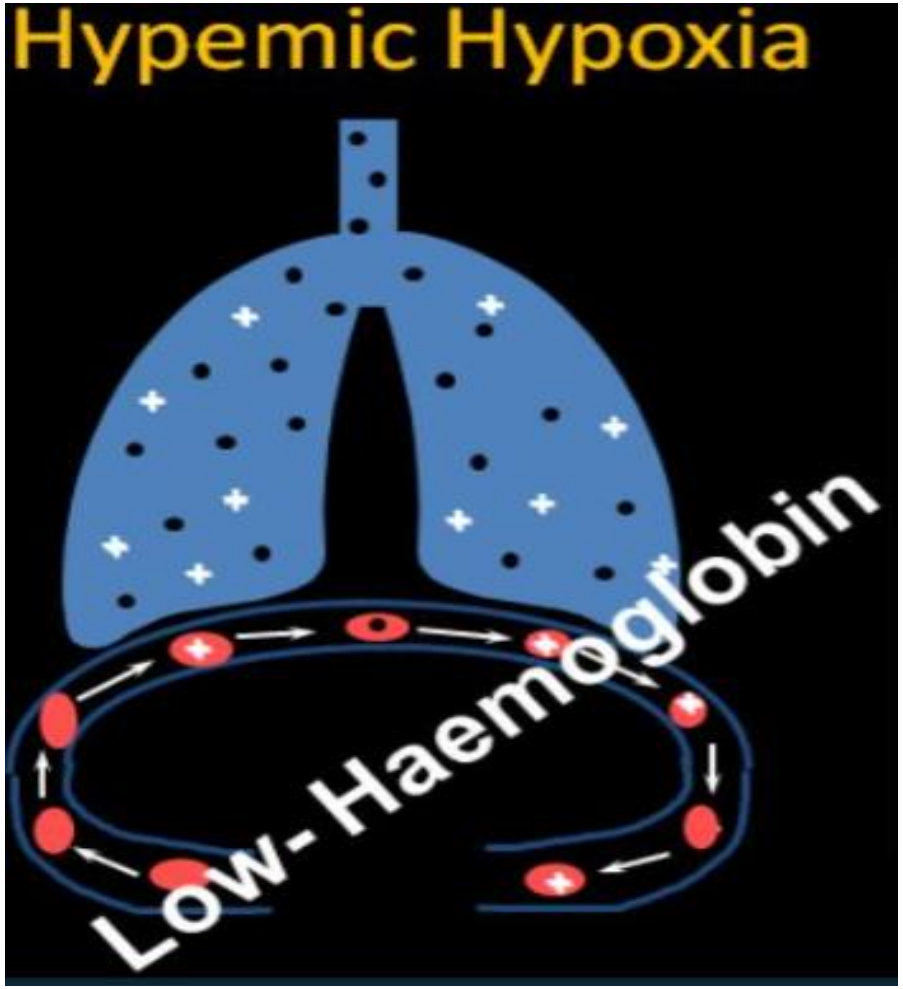
- Hypoxia; inadequate oxygen in tissues for normal cell and organ function.

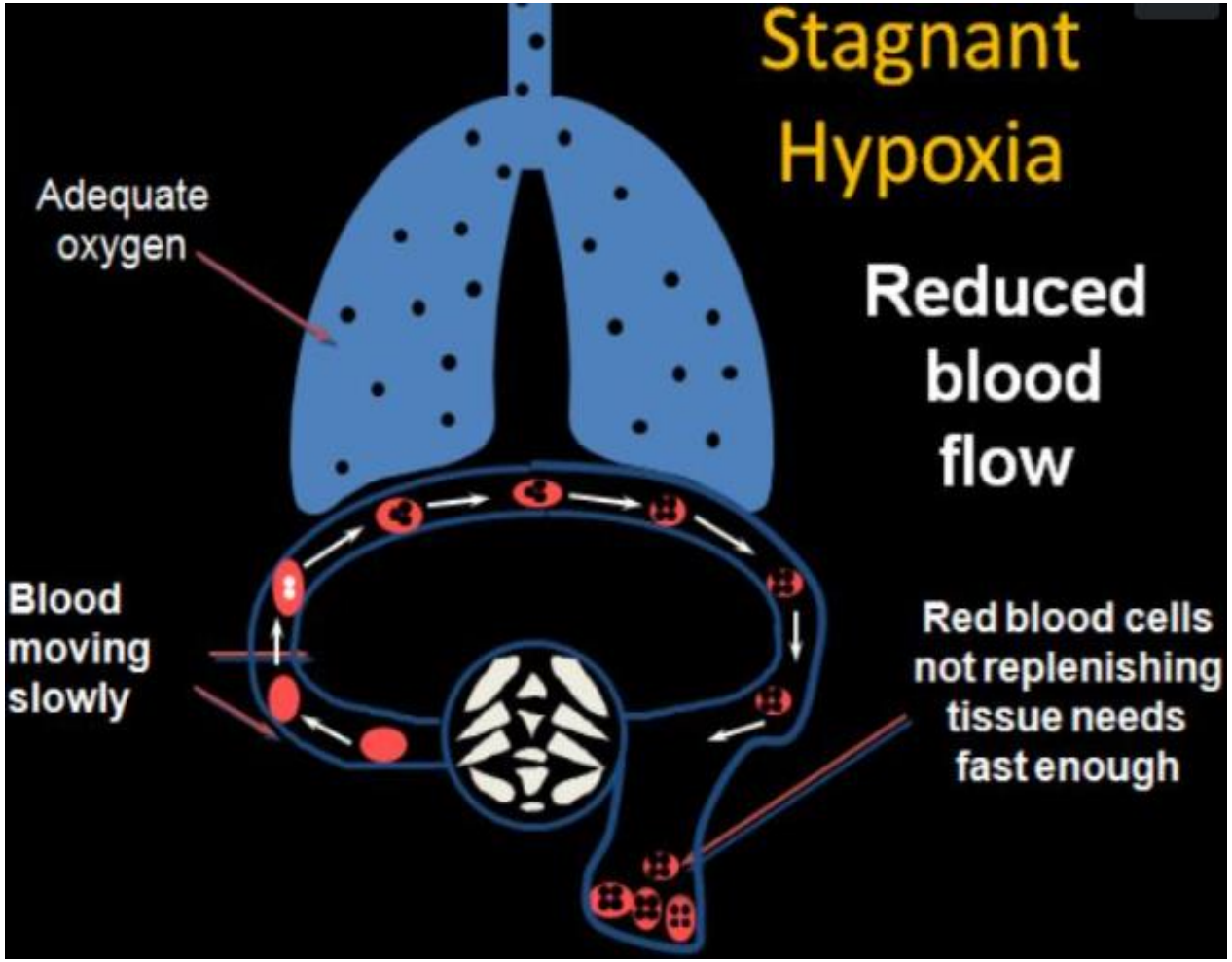
Hypoxaemia occurs frequently in diseases like;

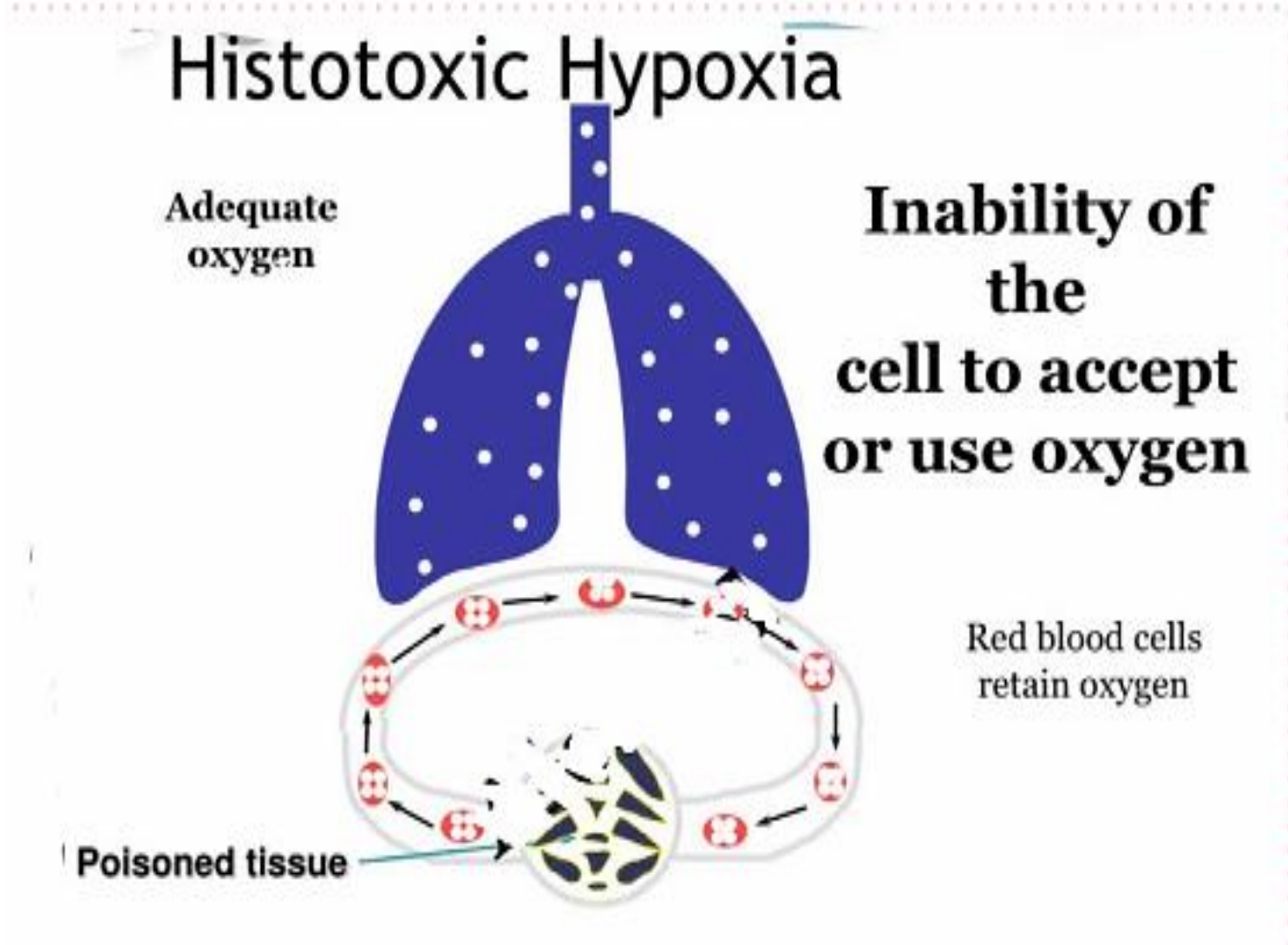
pneumonia or bronchiolitis, upper airway obstruction, asthma, birth asphyxia, RDS, sepsis, heart failure, cardiac arrest …

- hypoxaemia is a life-threatening condition that requires early detection and treatment.


Hypoxic Hypoxia (Altitude Hypoxia)
A deficiency in Alveolar oxygen exchange
Reduced O_2 in the lungs (high altitude)
Red blood cells
Body tissue


Hypemic Hypoxia
Low- Haemoglobin


Stagnant Hypoxia
Adequate oxygen
Reduced blood flow
Blood moving slowly
Red blood cells not replenishing tissue needs fast enough


Histotoxic Hypoxia
Adequate oxygen
Inability of the cell to accept or use oxygen
Red blood cells retain oxygen
Poisoned tissue

Hypoxaemia

Threshold at which hypoxaemia is defined and oxygen is given:

- In practice, the threshold at which oxygen is given often SpO2< 90%

It was found that 13% of children with pneumonia were hypoxaemic at SpO2 < 85%, 26% at SpO2 < 90% and 44% at SpO2< 93%

- Severe anaemia, heart failure, septic shock or neurological illness; SpO2 is 90–94%

- Emergency signs (obstructed or absent breathing, severe respiratory distress, central cyanosis, signs of shock, convulsions); SpO2 is< 94%

Acute respiratory infections

Hypoxaemia is a common complication in pneumonia and bronchiolitis: strong risk factor for death in developing countries.

The prevalence of hypoxaemia in referral hospitals; exceed 50%

- Pneumonia: bacteria (*Streptococcus pneumoniae* and *Haemophilus influenzae*), viruses (respiratory syncytial virus, influenza virus).

influenza are a potential risk, and effective oxygen systems are needed in all countries.

Detection of hypoxaemia

- **clinical signs**;

blue colouring of the tongue or gums (central cyanosis). If unsure, compare the colour of the child's tongue with that of the mother's.

Blue discoloration of the nail-beds indicates peripheral cyanosis (vasoconstriction as a result of hypothermia, exposure to low environmental temperature or circulatory shock).

nasal flaring, inability to drink or feed (when due to respiratory distress), grunting and depressed mental state (i.e. drowsy, lethargic).

Detection of hypoxaemia

Children with the following less specific signs may have hypoxaemia:

- **Increased respiratory rate**

An increase in respiratory rate (>70 breaths/min in children aged 2 months to 5 years), but the respiratory rate is affected by age, malnutrition and the presence of anaemia or fever.

It is best measured by observing the movement of the chest wall 60 s.

Detection of hypoxaemia

- **Severe lower chest indrawing**

is a key sign in the diagnosis of pneumonia

In the absence of pulse oximetry; classified as having severe respiratory distress and given oxygen.

- **Head nodding**

the head nods downwards towards the chest each time the child breathes; use of accessory muscles in breathing

Detection of hypoxaemia

- **Pulse oximetry** is the most accurate non-invasive method for detecting hypoxaemia.

The technology is robust and the cost quite low.

Pulse oximeters can be used to both detect and monitor hypoxaemia, make more efficient use of oxygen supplies and improve patient monitoring.

Fig. 9. Pulse oximeter showing a normal reading

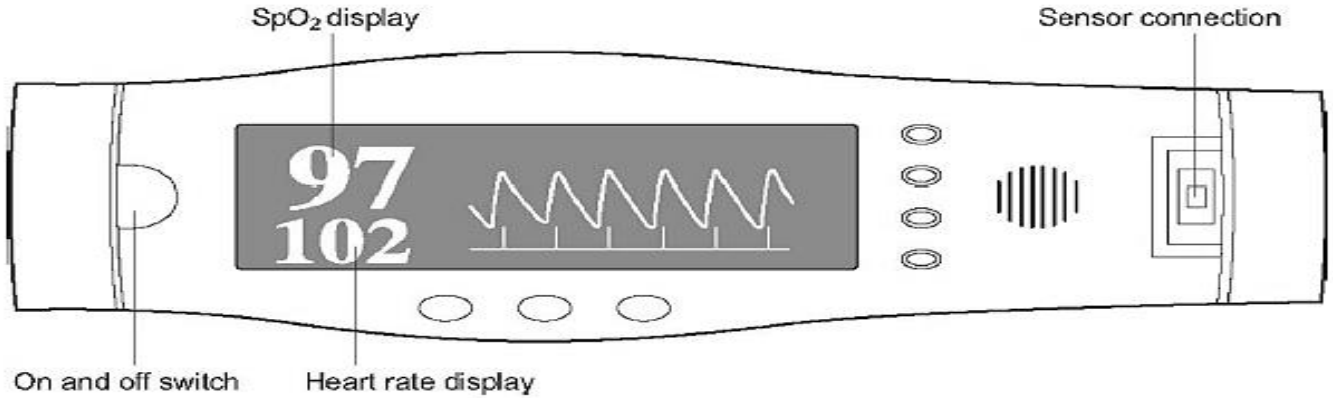
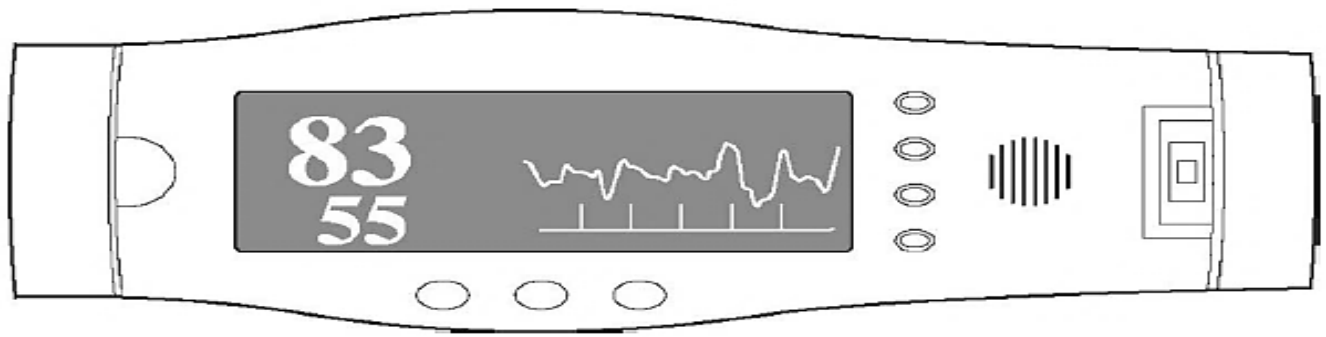


Fig. 10. Pulse oximeter showing a poor plethysmographic (pulse) wave



Detection of hypoxaemia

- **Blood gas analysis** is another very accurate method for detecting hypoxaemia.

The method has several drawbacks; Blood gas analysers are very expensive which may be unaffordable for hospitals with limited resources.

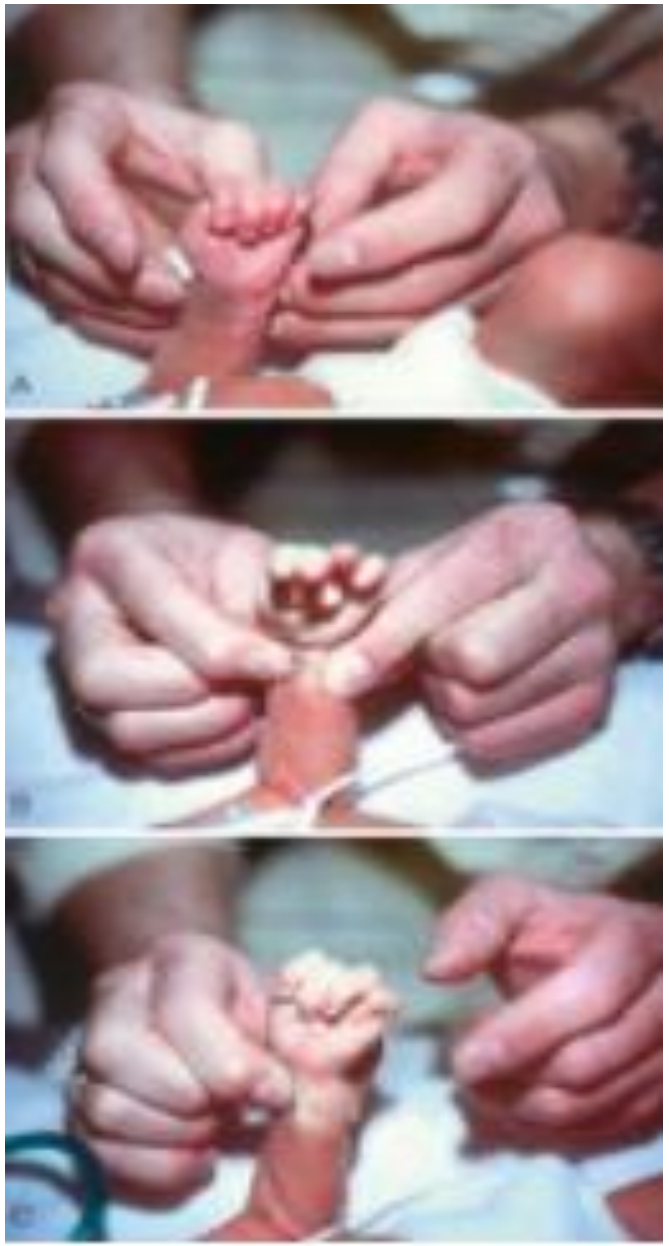
Inaccurate measurements can easily result from factors; poorly taken sample, delay in transfer of the sample to a laboratory,

blood gas analysis is not suitable for most hospitals with limited resources.

Allens Test;

۱. اگر از شریان رادیال استفاده می کنید، تست آلن انجام دهید تا از باز بودن شریان اولنار مطمئن شوید.
۲. برای انجام تست، روی شریان های اولنار و رادیال فشار وارد کنید، تا دست از خون خالی شود.
۳. سپس فشار را به آرامی بردارید و تغییر رنگ دست را بررسی کنید.
۴. اگر دست در مدت ۱۰ ثانیه با خون پر شود، بدین معنی است که خونگیری شریانی از این دست، ایمن می باشد.
۵. چنانچه برگشت خون بیشتر از ۱۵ ثانیه طول کشید، از شریان رادیال خونگیری انجام نشود.

Allens Test;



Methods of delivery oxygen

- **non-invasive;** face mask, Oxygen Hood, tent or holding tubing close to an infant's face.
- **semi-invasive;** insertion of prongs or catheters into the upper airway

Nasal prongs or nasal cannulae:

- Preferred method to infants and children<5 years.
- Standard flow rates: 0.5–1 L/min for neonates, 1–2 L/min for infants, 1–4 L/min for older children.
- Humidification is not required with standard oxygen flow rates.

Nasal prongs or nasal cannulae

FiO2 depends on the oxygen flow rate, prong and nasal diameters and the patient's BW.

- oxygen flows of 0.5 L/min, 1 L/min and 2 L/min; FiO2 35%, 45% and 55%
- PEEP production with is unpredictable.
- 1 L/min of oxygen may produce a PEEP of about 5 cm/H2O in premature infants, there is no significant PEEP production with the same flow in infants weighing up to 10 kg.

Methods of delivery oxygen

- **Nasal catheter**

The maximum flow rate should be set at 0.5–1 L/min for neonates and 1–2 L/min for infants and older children.

The oxygen does not have to be humidified, because the tip of the catheter lies in the nasal cavity.

Catheters can become blocked with mucus, which can cause upper airway obstruction.

In neonates and infants, 8-F size catheters should be used.

Correct position of nasal catheter (cross-sectional view)

Methods of delivery oxygen

- **Nasopharyngeal catheters**

The maximum flow rate should be set at 0.5 L/min for neonates and 1 L/min for infants.

In neonates and infants, 8-F catheters should be used.

significant PEEP production: in infants 1 L/min given through an 8-F catheter produces a PEEP of 2.8

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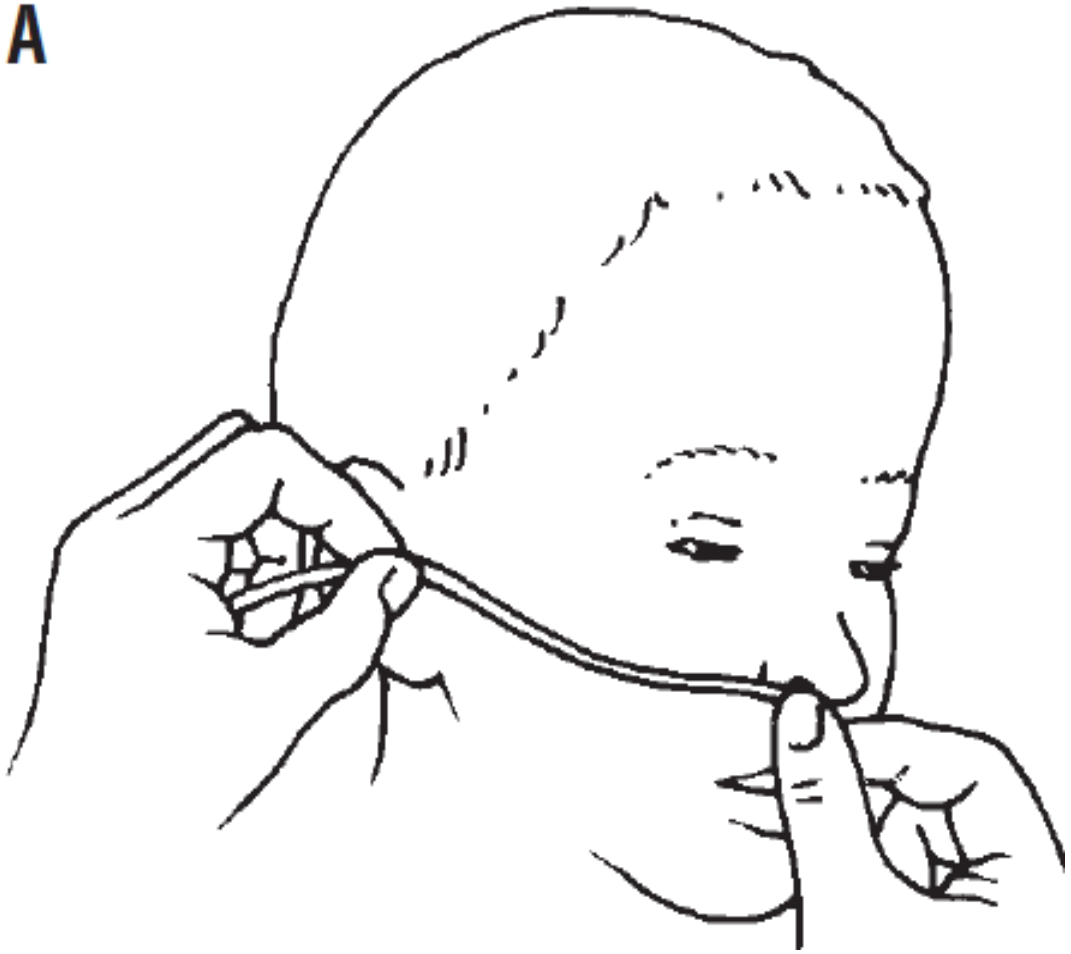
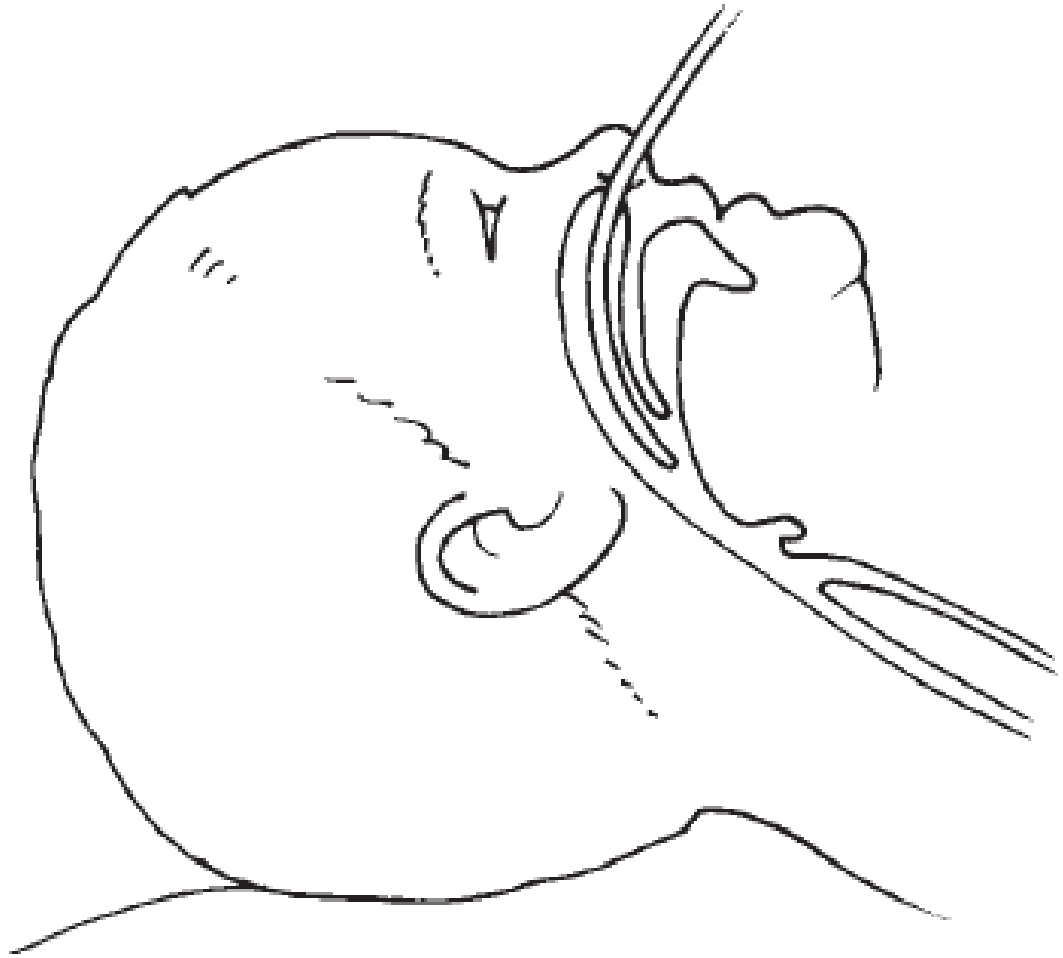




Methods of delivery oxygen

problems;

- prone to blockage with mucus, and accumulation of mucus can cause upper airway obstruction.
- oxygen should be humidifying and warming
- gastric distension (nasogastric tube should also always be in place)
- trained personnel are need for monitoring and supervision (infants and children with croup).

Methods of delivery oxygen

✓**Face-mask:** (5-10 lit/min), Fio2: 60%

✓**Partial Rebreathing mask:** (6-15 lit/min), Fio2: 70%

✓**Non-Rebreathing mask:**(10-15 lit/min), Fio2: 90%

✓**Oxygen Hood:**

- FiO2 can be determined with an oxygen analyser placed near the infant's mouth.

- **major concern:** carbon dioxide toxicity can occur if the flow of oxygen is inadequate.

2–3 L/kg/min is necessary to avoid rebreathing of carbon dioxide in a head box in infants.

Methods of delivery oxygen

- If nasal prongs are used at maximum flow and the child is still hypoxaemic:
- give a second source of oxygen via an oxygen mask (ideally with a reservoir bag)
- If a second source of mask oxygen is not available, insert a nasopharyngeal catheter

Humidification

- Humidification is not necessary through a nasal catheter or nasal prongs (0.5–1 L/min for a neonate, 1–2 L/min for an infant, 1–4 L/min for an older child)
- When oxygen is delivered at a higher flow rate (>4 L/min) humidification is necessary.
- Humidification is essential when cold oxygen is delivered from a cylinder.
- Humidification is needed when oxygen is given via a nasopharyngeal catheter.

Humidification

- A major concern with regard to water humidifiers is **bacterial contamination.**

- In one study, prefilled disposable reservoirs were found to be pathogen-free for up to 3 days.

- Humidifiers filled with tap water were not contaminated more frequently than those containing sterile water.

Monitoring the progress of children on oxygen

- In severe pneumonia, hypoxaemia can last from several hours to several weeks; the usual duration is 2–5 days.

adequacy of ventilation depend on;

- airway is clear
- patient is positioned to facilitate chest expansion (e.g. sitting in a semi-recumbent position at 20–30°)
- head up to reduce diaphragmatic splinting if there is abdominal distension
- passing a nasogastric tube to deflate the stomach

Monitoring the progress of children on oxygen

A nurse should check every 3 h;

- the prongs or catheter are in the correct position and not blocked with mucus
- all connections are secure
- the oxygen flow rate is correct
- the airways are not obstructed by mucus and that there is no gastric distension
- Prongs or catheters should be removed and cleaned at least twice a day.

When to stop oxygen

- At least once each day, children who are clinically stable (have no emergency signs and SpO2>90%).
- Children who are clinically stable should be disconnected from oxygen for 10–15 min and carefully examined.
- If respiratory distress; child should be immediately restarted on oxygen.
- Supplemental oxygen is best interrupted first thing in the morning.

General care of children with hypoxaemia

minimal handling, positioning, fluids, nutrition and close monitoring

- Handling can be upsetting to severely ill children, and consumes more oxygen.
- Painful procedures should be avoided
- breathing may improve if head raised about 30°
- Some hypoxic infants and young children may be more stable in the prone position

General care of children with hypoxaemia

- Withhold oral feeds while the child has severe chest indrawing or severe respiratory distress to avoid the risk for aspiration.

- **Do not give large volumes of intravenous fluids**; worsen hypoxaemia

- Do not give large nasogastric feeds to children with severe respiratory distress: vomit and aspirate

Overcoming parents' concerns about oxygen use

- Parents must be educated about the need for oxygen
- Show parents the pulse oximeter in operation and explain to them why the child's oxygen level is low.
- Show parents the clinical signs (chest indrawing or cyanosis of the gums or tongue)
- When oxygen is given, the parents will see that the SpO2 increases and the child's respiratory distress lessens.

Nebulizers

- Nebulizer are used to provide aerosol therapy to patient too ill or too young to use handling devices and in situations where large drug doses are necessary.

- These devices also are required for some medications available only in liquid form including saline (3%, 5%, 7%- tobramycin, DNA ase, …).

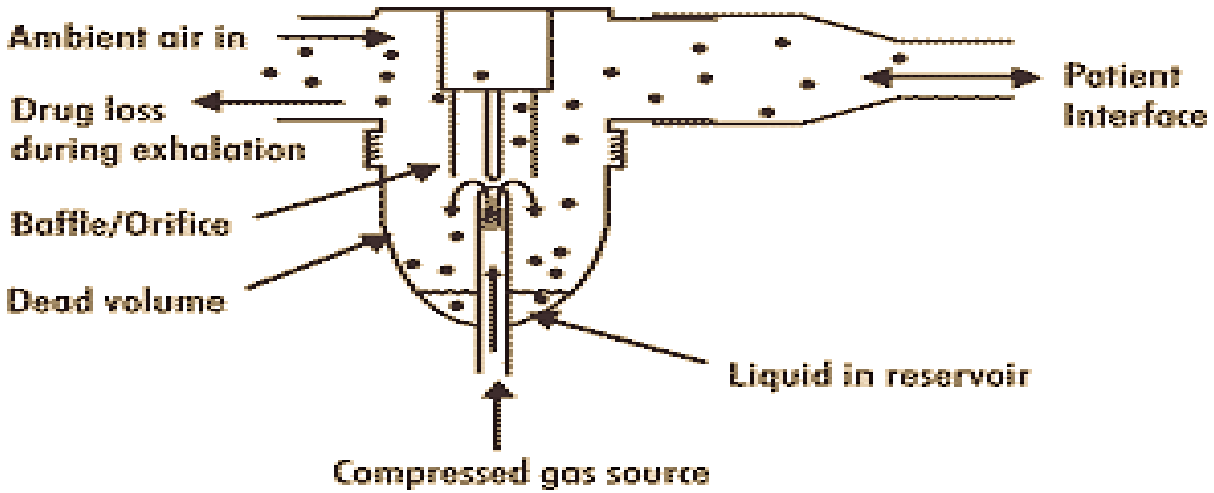
Basic types of nebulizer

- Jet nebulizers
- Ultrasonic nebulizer
- Vibrating mesh nebulizer

Jet nebulizers

- Are the most frequently used form of nebulizer in the clinical setting.
- Utilize a driving gas of compressed air or oxygen through a jet.
- Generation of smaller, respirables particle of 1 to 5 microm in size.

Figure 1: Functioning of Pneumatic Jet Nebulizer



Factors affecting JET nebulizer performance

- **Nebulization time:** the majority of nebulized dose is delivered during first five minutes in most cases and little additional is gained by beyond 5 to 10 minutes.

- **Age:** total lung deposition of starting medication ranging from approximately 2 percent up to 20 percent or greater with more efficient nebulizers.

Factors affecting JET nebulizer performance

Driving gas:

Many jet nebulizers are not capable of delivering flow rates this high, resulting in a large aerosol particles.

Dead volume:

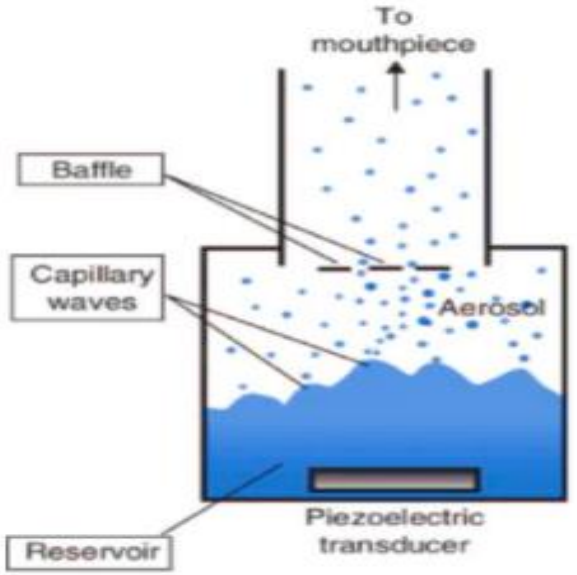
- The amount of wasted drug can be reduced by adjusting the starting volume of nebulizer solution to at least 4 ml (3-6ml).
- Tapping on the nebulizer chamber during nebulization may further reduce dead volume.

Other factors

- The level of cooperation of the patient
- Changes in breathing patterns, such as occurs with persistent cough.
- Type of face mask used
- The filters on the medical compressor units should be changed every approximately 6 month.

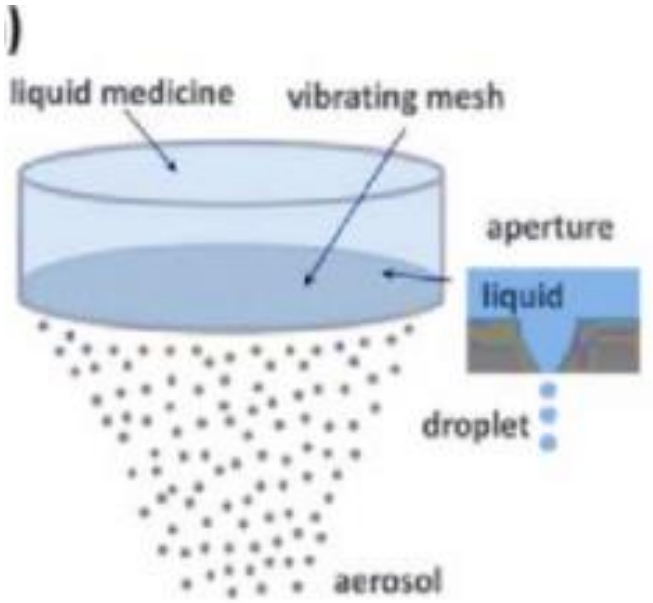
Ultrasonic nebulizers

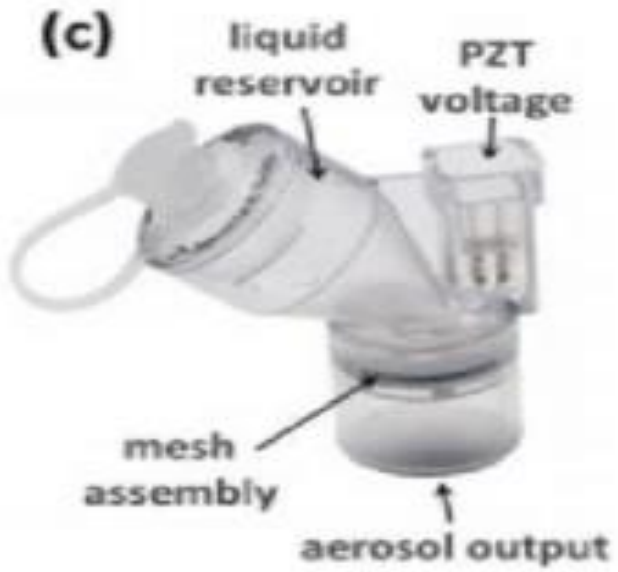
- Ultrasonic nebulizers consist of a power unit and transducer
- Electrical energy from the power unit is converted to high-frequency ultrasonic waves by a piezoelectric element in the transducer.
- Ultrasonic waves are transmitted to the surface of the solution to create an aerosol.



Mesh nebulizers

- Mesh nebulizers use a perforated membrane to generate the aerosol.
- Electronic nebulizers can generate aerosolized particles that are highly uniform and respirables.
- Deliver drugs in less than five minute.





Types of nebulizers	Advantages	Disadvantages
Jet	• Less expensive • Enhanced designs have improved performance and reduced aerosol waste during the exhalation phase	• Require a source of compressed air or oxygen • Lower efficiency
Ultrasonic *	• Do not require a source of driving gas • Can nebulize large volumes of liquid • Shorter delivery time than jet nebulizers	• Larger aerosolized particle sizes • High density aerosols can cause bronchospasm and increased airway resistance • Lower efficiency • May breakdown complex molecules
Vibrating mesh	• Do not require a source of driving gas • Shorter delivery time than jet nebulizers • Aerosolized particles are highly uniform and respirable • More portable (light weight and smaller size) • More efficient than jet nebulizer (minimizes drug waste)	• More expensive • Require disassembly and cleaning after each use

Infection control

- Standardized guidelines for disinfecting nebulizers are not available.

- It is also recommended that nebulizers be disinfected by soaking one to two times per week in an acetic acid solution for 30 minutes (one part distilled white vinegar to three parts warm water), or in a commercial quaternary ammonium compound for 10 minutes.

- The final rinse should be with tap water.

Allergen control

- The nebulizers also may be contaminated by indoor allergens.

- Proper cleaning of nebulizers, and storage of nebulizers in plastic bags may prevent contamination with allergens.

2.1 Procedure / Process for Nebuliser Administration	
No.	Action
1	If the nebuliser is to be administered for respiratory distress, stridor or asthma a set of observations should be recorded pre nebuliser.
2	For children with asthma, check whether peak flow should be recorded pre and post nebuliser. If so, record prior and 15 minutes following nebuliser and record on designated chart.
3	For a child with croup, record observations of pulse and respiratory rates, respiratory effort and oxygen saturations prior to administration of nebulised Adrenaline. Continue observations during Adrenaline nebuliser and for 3 hours afterwards because of risk of rebound phenomena during this time leading to increased severity of symptoms (BNFC 2018). - pulse - ECG - oxygen saturation - respiratory rate Hourly observations of above to be recorded and charted, to include respiratory effort. Appearance of side effects or increased symptoms to be notified immediately to relevant medical staff.

4	Obtain verbal consent from the child and their family to administer the nebuliser, use appropriate language to explain the procedure to the child.
5	Select appropriate size of face mask or mouthpiece if child is able to tolerate this. Facemasks should be applied closely to the face throughout administration (a gap of a few cm reduces lung deposition, Booker 2007). If appropriate for the child a mouthpiece is preferred for the administration of corticosteroids (to avoid contact with facial skin and eyes) anticholinergics (to avoid contact with eyes) and antibiotics (to avoid skin contact, Kelly 2011). It also results in higher lung deposition of the medication rather than via a face mask. For a child with a tracheostomy who is self-ventilating, ensure that a tracheostomy mask is used (never administer directly to tracheostomy tube). For a ventilated child administer via the ventilator circuit (see Tracheostomy UHL Childrens Hospital Guideline 2021)
6	Ensure that a filter system is incorporated into nebuliser if indicated e.g. nebulised antibiotics e.g.(see appendix 1 for diagram of set up)

7	Wash hands before preparing and administering nebuliser. Avoid touching the inside of the nebuliser pot to avoid contaminating reservoir (O'Malley 2015). Prepare and check medication in accordance with UHL medicine administration policy. Where a child is receiving a proportion of a nebule, dilute to a minimum of 2.5ml with 0.9% sodium chloride to ensure adequate droplet formation. Do not exceed a maximum of 5ml because this will reduce nebuliser performance and prolong administration time (Kelly 2011).
8	Use oxygen or air as indicated to generate aerosol formation of the medication. Ensure an appropriate flow rate is maintained to administer the nebuliser (follow manufacturer's guidance but generally: disposable system 5-8 litres per minute and 2-4 litres per minute for Pari-neb, Booker 2007). Run until characteristic 'spluttering sound is heard, gently tap the chamber and continue to run until 'spluttering' is heard again. Nebulisers take on average 5 to 10 minutes to administer depending on the volume nebulised.

	A residual volume of 0.5-1.5ml will remain and this liquid should be discarded at the end of nebulisation (Boe et al 2001). For children using their portable nebuliser system, this runs using air via a compressor and mains electricity.
9	If appropriate for the child encourage them to sit up straight to receive their nebuliser and take normal steady breaths with interspersed occasional deep breaths to optimise drug delivery (LLRRPG 2018). For younger children tilt the bed to give a more upright position if appropriate. If using a Pari nebulizer system, use the 'bendy arm' to facilitate nebulization in the lying/laid back position.
10	Clean the nebuliser 'pot' and mask/mouthpiece with soap and water in a disposable bowl. Rinse with sterile water (O'Malley 2015). Discard dirty water in the sluice. Leave covered to air dry between use. Disposable nebuliser equipment is for single patient use and should be changed at least every 7 days or earlier if equipment is damaged.