SECTION 7: Advanced Life Support (IMEESC section 13 and WHO Pregnancy C-43)

Airway and Breathing

Management of the Airway (A) and Breathing (B) components of the ABC has priority in all situations. Resuscitation will fail if effective ventilation does not occur.

Before effective resuscitation techniques can be applied, it is essential that the operator is able to

1. Understand the airway equipment available and how to use it
2. Recognise respiratory failure and when it may occur
3. Perform a systematic and prioritised approach (the structured ABC approach) to the management of the infant, child or pregnant woman or girl who has a problem of the airway or breathing (see Section 8)

Airway: Equipment and skills for opening and maintaining the airway

Essential airway and breathing equipment

- face masks (ideally with reservoirs)
- airways including laryngeal mask airways (LMAs) if anaesthetic skills are available
- self-inflating bag–valve–mask devices
- tracheal tubes, introducers and connectors
- laryngoscopes
- McGills forceps
- suction devices
- surgical airway packs for performing an emergency surgical airway

This equipment should be available in all resuscitation areas, ideally in a resuscitation trolley. It is crucial that familiarity with it is gained before an emergency situation occurs.

Pharyngeal airways

There are two main types of pharyngeal airway:

1. Oropharyngeal
2. Nasopharyngeal

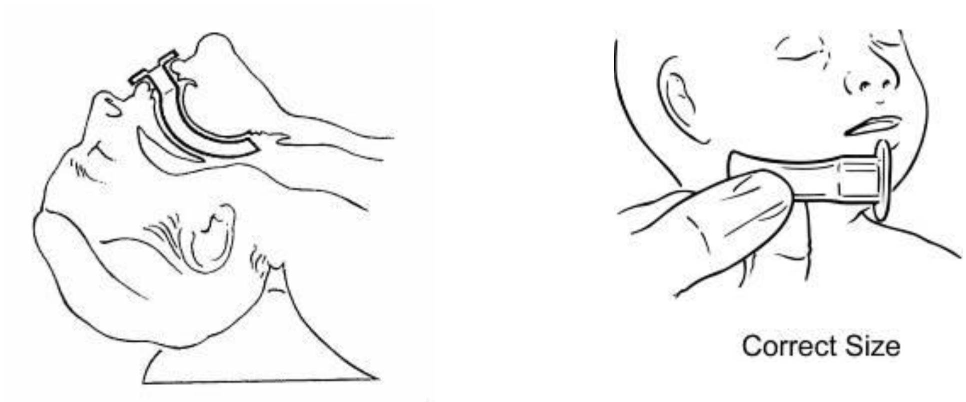


Figure Oropharyngeal airway showing insertion and sizing technique

1. The oropharyngeal or Guedel airway is used in the unconscious or obtunded patient to provide an open airway channel between the tongue and the posterior pharyngeal wall.

In the awake patient with an intact gag reflex, it may not be tolerated and may induce vomiting.

The oropharyngeal airway is available in a variety of sizes. A correctly sized airway when placed with its flange at the centre of the incisors, then curved around the face, will reach the angle of the mandible. Too small an airway may be ineffective, too large an airway may cause laryngospasm. Either may cause mucosal trauma or may worsen airway obstruction. Reassessment following placement is therefore a vital part of safe insertion of an airway device.

There are two methods for inserting the oro-pharyngeal airway in a child depending on whether the child is small or large – however there is no especial age for change – it depends on practicality and skills of operator. The important issue is not to push the tongue back by inserting carelessly.

The twist technique is used for the larger child and in pregnancy and means that the convex side of the airway is used to depress the tongue as the airway is pushed into the mouth. Insert the airway upside down until the tip has passed the soft palate and then rotate it 180º so that the natural curve of the Guedel airway follows the curve of the tongue and pharynx.

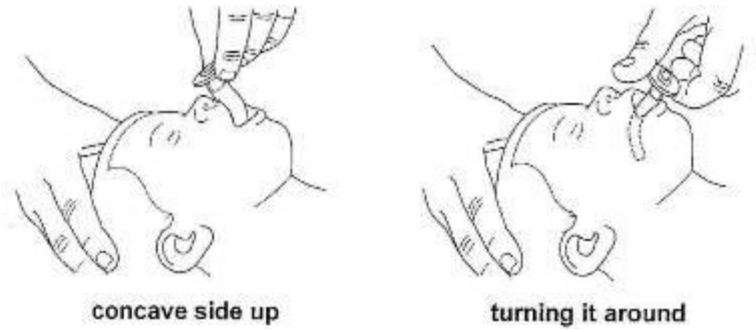


Figure Oropharygeal airway shown being inserted concave side up, then in place concave side down

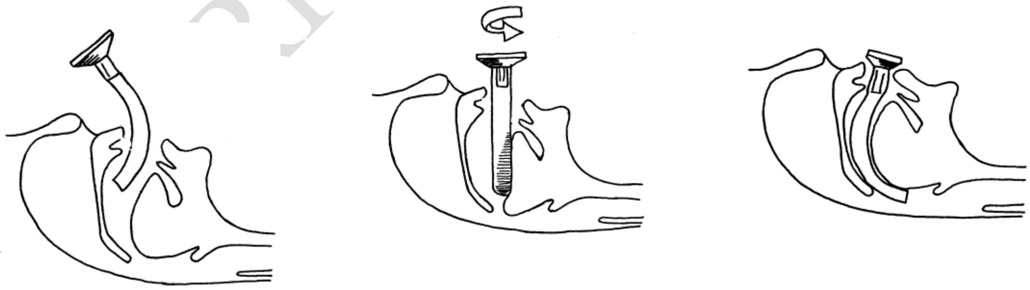


Figure Inserting an oropharyngeal airway in a large child or adult

However, in the infant and small child, as the tongue is bigger relative to the size of the mouth, the airway cannot be rotated in the mouth without causing trauma; hence the tongue is depressed with a spatula and not by the reversed airway.

Figure Inserting an oro-pharyngeal airway in an infant or young child (that is without rotation). A tongue depressor will be needed.

Ensure that insertion of one of these devices results in improvement in the patient's airway and breathing. It if does not improve the airway as shown by improved breathing, then a reappraisal of the choice or size of airway is urgently required.

2. The nasopharyngeal airway is often better tolerated than the Guedel airway. **It is contraindicated in fractures of the base of the skull.** It may also cause significant haemorrhage from the vascular nasal mucosa if not inserted with care, preferably lubricated. A suitable length can be estimated by measuring from the lateral edge of the nostril to the tragus of the ear. An appropriate diameter is one that just fits into the nostril without causing sustained blanching of the alae nasi. As small-sized nasopharyngeal airways may not be available, shortened endotracheal tubes may be used.

The test of success, as in all therapeutic interventions, is that insertion of one or other of these devices should result in improvement in the patient's condition. If it does not occur then a reappraisal of the choice or size of airway is urgently required.

In pregnancy, the nasopharyngeal tube is not much used because of the tendency to nasal mucosal bleeding in pregnancy.

Laryngoscopes

Two principal designs of laryngoscope exist: straight bladed and curved bladed.

The straight-bladed laryngoscope is usually employed to directly lift the epiglottis, thereby uncovering the vocal folds. The advantage of this approach is that the epiglottis is moved sufficiently so that it does not obscure the cords. The potential disadvantage is vagal stimulation causing laryngospasm or bradycardia.

The curved-bladed laryngoscope is designed to move the epiglottis forward by lifting it from in front. The tip of the blade is inserted into the mucosal pocket, known as the vallecula, anterior to the epiglottis and the epiglottis is then moved forward by pressure in the vallecula. This may be equally effective at obtaining a view of the cords and has the advantage that less vagal stimulation ensues, as the mucosa of the vallecula is innervated by the glossopharyngeal nerve instead.

A laryngoscope blade should be chosen appropriate for age. It is possible to intubate with a blade which is too long but not one which is too short.

Laryngoscopes are notoriously unreliable pieces of equipment which may develop flat batteries and unserviceable bulbs very quickly between uses. It is vital, therefore, that a spare should be available at all times and that equipment should be regularly checked to ensure it is in good working order.

Tracheal tubes

Uncuffed tubes should be used during resuscitation, by those who do not have paediatric anaesthetic experience, for children up until approximately 10 years of age. If familiar with cuffed tube placement, both cuffed and uncuffed tubes are acceptable for infants and children undergoing emergency intubation but not neonates. Until the age of about 10 years, the larynx is circular in cross section and the narrowest part of it is at the cricoid ring, rather than the vocal cords. An appropriately sized tube should give a relatively gas-tight fit in the larynx but should not be so tight that no leak is audible when the bag is compressed. Failure to observe this condition may lead to damage to the mucosa at the level of the cricoid ring and to subsequent oedema following extubation.

Estimating the appropriate size of an uncuffed tracheal tube is carried out as follows:

Internal diameter (mm) = (Age/4) + 4
Length (cm) = (Age/2) + 12 for an oral tube
Length (cm) = (Age/2) + 15 for nasal tube

These formulae are appropriate for ages over 1 year. Neonates usually require a tube of internal diameter 3–3.5 mm, although pre-term infants may need one of diameter 2.5 mm. Cuffed tubes should not be used in neonates.

For cuffed tracheal tubes, an estimate of the appropriate internal diameter for children from 2 years is carried out as follows:

Internal diameter (mm) = (Age/4) + 3.5

For infants of more than 3 kg and up to one year a size 3 cuffed tube and from 1-2 years a size 3.5 cuffed tube are usually acceptable

Tracheal tubes are measured in sizes by their internal diameter in millimetres. They are provided in whole-and half-millimetre sizes. The clinician should select a tube of appropriate size but also prepare one a size smaller and one a size larger.

In the circumstance of resuscitation in a young child where the lungs are very "stiff", for example in a cardiac arrest from severe bronchiolitis, a cuffed tube rather than an uncuffed tube may be used by a non-expert but the risk of airway damage from the cuff must be balanced against the risk of failure to inflate the lungs.

In pregnancy, cuffed tubes must be used because of the high risk of gastric reflux in the pregnant patient causing aspiration of acid gastric material and severe respiratory problems.

Tracheal tube introducers

Intubation can be facilitated by the use of a stylet or introducer, placed through the lumen of the tracheal tube. There are two types: soft and flexible or firm and malleable.

The former can be allowed to project out of the tip of the tube, as long as it is handled very gently. The latter is used to alter the shape of the tube, but can easily damage the tissues if allowed to protrude from the end of the tracheal tube. Tracheal tube introducers should not be used to force a tracheal tube into position.

Bougies which are flexible, deformable, blunt ended gum elastic rods of different sizes can be used to help introduce a tracheal tube when access is difficult. A Seldinger type technique is used. The bougie is introduced into the trachea using the laryngoscope and then the endotracheal tube passed over it into the trachea and then the bougie is removed.

In pregnancy:
1. A 15 French bougie should be used for endotracheal tube sizes 6.0 to 11.0.
2. Lubricate bougie with KY jelly.
3. Perform laryngoscopy. If cords not visible, identify landmarks to aid intubation.
4. Place bougie into the pharynx and direct into larynx. If necessary, bend the bougie to negotiate the corner. Correct placement may be confirmed by detection of tracheal "clicks" and "hold up" of the bougie - no hold up indicates oesophageal placement.
{Header 3}6. Hold the tube firmly in place and gently withdraw the bougie.
7. Remove laryngoscope and confirm tube placement as usual.

Tracheal tube connectors
In pregnancy, the proximal end of the tube connectors is of standard size, based on the 15–22-mm system, ensuring that they can be connected to a standard self-inflating bag.

The same standard system exists for children, including neonates.

Magill's forceps
Magill's forceps are angled to allow a view around the forceps when in the mouth. They may be useful to help position a tube through the cords by lifting it anteriorly, or to remove pharyngeal or supra-glottic foreign bodies.

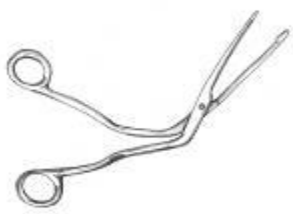


Figure Magill's forceps

Suction devices
These are used to remove blood, vomit and secretions from the mouth and throat usually with a rigid suction tube (Yankauer: see below). In resuscitation areas, ideally the suction device should be connected to a central vacuum unit. This consists of a suction hose inserted into a wall terminal outlet, a controller (to adjust the vacuum pressure), a reservoir jar, suction tubing and a suitable sucker nozzle or catheter. In order to aspirate vomit effectively, it should be capable of producing a high negative pressure and a high flow rate, although these can be reduced in non-urgent situations, so as not to cause mucosal injury.

Portable suction devices are required for resuscitation when central suction is not available (most poorly resourced hospitals), and for transport to and from the resuscitation room. These are either manual, mains electrical or battery powered. A manual or battery operated suction system must be available in all sites where resuscitation may be needed.

To clear the oropharynx of debris eg.vomit a rigid sucker (e.g. Yankauer) should be used with care not to damage delicate tissue or induce vomiting. The Yankauer sucker is available in both adult and paediatric sizes. It may have a side hole, which can be occluded by a finger, allowing greater control over vacuum pressure.

Tracheal suction catheters

These may be required after intubation to remove bronchial secretions or aspirated fluids. In general, the appropriate size in French gauge is numerically twice the internal diameter in millimetres, e.g. for a 3-mm tube the correct suction catheter is a French gauge 6.

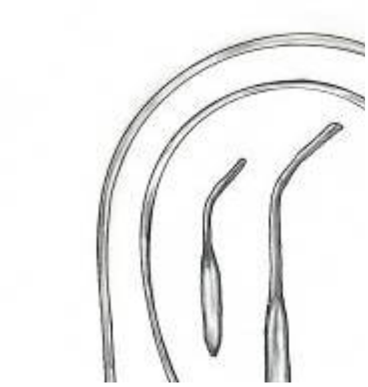


Figure Tracheal suction catheters

Advanced airway techniques

Advanced airway techniques are used when the above techniques fail to maintain and protect an airway over the longer term; particularly if there is potential for it to become obstructed and to prevent accurate control of oxygenation and ventilation. Advanced airway techniques (tracheal intubation, surgical cricothyroidotomy and surgical tracheostomy) are described below.

Breathing: equipment and skills for helping the patient to breathe

The following equipment for oxygenation and ventilation should be readily available:

- oxygen source and masks for those who are spontaneously breathing
- close fitting face masks (for artificial ventilation)
- self-inflating bag valve systems to be used with close fitting face masks
- T-piece and open-ended bag systems (for those with anaesthetic skills only)
- mechanical ventilators
- chest tubes
- gastric tubes

Oxygen treatment

Indications
Give oxygen if there is respiratory distress (severe lower chest wall in-drawing (recessions), raised respiratory rate, gasping, grunting with each breath, nasal flaring, head bobbing etc.) or if cyanosis (blueness) is central (around lips and tongue or inside mouth in children with dark skin) or if shocked or if fitting and if unconscious and oxygen saturation ($SaO_{2)}$ is abnormal on a pulse oximeter.

Where available and ideally, oxygen therapy should be guided by pulse oximetry (see below). Give oxygen to children with $SaO_2 < 94\%$ and aim to keep SaO2 94-98% (unless at high altitude where normal oxygen saturation levels are lower. Where pulse oximeters are not available, the need for oxygen therapy needs to be guided by clinical signs, which are less reliable.

Provision of oxygen

Oxygen (O_2) must be available at all times. The two main sources of oxygen are cylinders and oxygen concentrators.

O_2 cylinders contain compressed gas. A flow meter needs to be fitted to regulate flow. A hissing noise can be heard if gas is being delivered.

Flow meters are used to ascertain how much O_2 is being delivered. Take the reading of flow rate from the middle of the ball. Always switch off flow when not in use (ensure indicator ball at bottom of flow meter and not moving).

DO NOT leave anything inflammable near to the O_2 supply. DO NOT ALLOW SMOKING near to O_2.

At least once a day, check that an adequate O_2 supply is available (use a signed log book). If gauge indicating amount left in cylinder is not available, switch on flow and listen to hiss. Replace empty cylinders promptly. Ensure cylinders are stored in an upright position in suitable containers so that they are secure and cannot fall over, which can cause injury. Cylinder keys to permit changes of regulator should be tied to each cylinder.

Oxygen concentrators may be available. They give >95% oxygen with a flow of 1 to 8 liters/minute but unlike cylinders, require continuous electricity. For this reason, all areas where patients might need oxygen must have both cylinders and concentrators.

There are now small oxygen plants available that can provide either oxygen for a defined area or even the whole of a hospital or health facility. Some can provide and fill oxygen cylinders as well, thereby providing a constant back up. www.ogsi.com

Oxygen delivery

A mask with a reservoir bag allows up to 100% oxygen to be delivered. Without a reservoir, it is only possible to deliver around 40%. If only low flow rates of oxygen are available, do not use a reservoir bag.

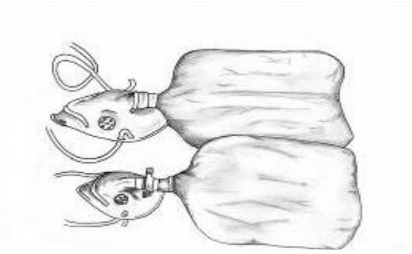


Figure Reservoir bags

If using an oxygen mask, ensure that mask is large enough to cover the mouth and nose. Both low and high flow O_2 (up to 15l/min) can be given. Hold mask in place using the elastic strap around back of head or with a young child, ask mother to hold it as close as possible to the child's face.

Nasal prongs/short cannulae are the preferred method of delivery in most circumstances as they safe, non-invasive, reliable and do NOT obstruct the nasal airway. The use of head boxes is not recommended as they use up too much oxygen and give a low concentration. Face masks can be used for resuscitation purposes, ideally with a reservoir attached to deliver 100% oxygen.

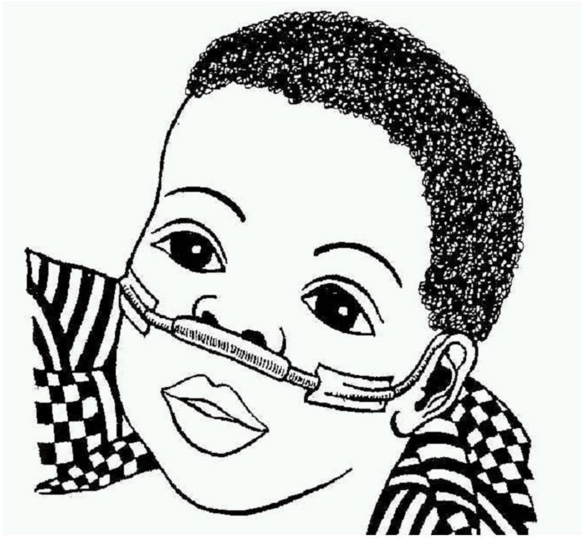


Figure Nasal cannula taped in place

Monitoring

Nursing staff must know how to place and secure the nasal prongs/cannulae correctly. Check regularly that the equipment is working properly, and remove and clean the prongs at least twice a day.

Monitor the patient at least every 3 hours to identify and correct any problems, including:

- SaO_2 by pulse oximeter
- nasal prongs out of position
- leaks in the oxygen delivery system
- oxygen flow rate not correct
- airway obstructed by mucus (clear the nose with a moist wick or by gentle suction)

Pulse oximetry

Normal oxygen saturation at sea level in a child is 95–100%. Oxygen is ideally given to keep oxygen saturations between 94-98%. Different cut-offs might be used at high altitude or if oxygen is scarce. The response to oxygen therapy in lung disease can be measured with the pulse oximeter as the patient's SaO_2 in the same flow of oxygen should increase (with cyanotic heart disease, SaO2 does not change when oxygen is given). The oxygen flow can be titrated using the pulse oximeter as a monitor to obtain a stable SaO2 94-98% without giving too much oxygen.

Duration of oxygen therapy

Continue giving oxygen continuously until the patient is able to maintain a SaO2 of 94% or higher in room air. When the patient is stable and improving, take them off oxygen for a few minutes. If the SaO2 remains between 94-98%, discontinue oxygen, but check again 1/2 hour later, and 3 hourly thereafter on the first day off oxygen to ensure the patient is stable. Where pulse oximetry is not available, the duration of oxygen therapy is guided by clinical signs, which are less reliable.

Breathing for the patient

Face masks with seal over nose and mouth for positive pressure ventilation

These are used for either mouth to mask or more commonly bag-mask ventilation. Masks are available in various sizes and the appropriate size to cover the mouth and nose should be chosen.

Face masks for mouth-to-mouth or bag/valve/mask ventilation in infants are of two main designs. Some masks conform to the anatomy of the patient's face and have a low dead space. Circular soft plastic masks give an excellent seal and are preferred by many. Children's masks should be clear to allow the child's colour or the presence of vomit to be seen.

A pocket mask is a single-size clear plastic mask with an air-filled cushion rim designed for mouth-to-mask resuscitation. It can be supplied with a port for attaching to an oxygen supply and can be used in adults and children. By using it upside down it may be used to ventilate an infant.

Figure Face masks with cushioned rim in various sizes (round for infants)

Self-inflating bags

This is one of the most important pieces of equipment allowing hand ventilation by facemask without a supply of gas. The two appropriate sizes are **500ml** and **1600ml (the smaller for infants <1 year and the larger for children and** pregnant women or girls**).** There is also a 250ml version for small premature babies. These bags have pressure-limiting valves that operate at between 30 and 45cm H_2O. **Test the valve** by placing the mask on a surface and pressing the bag and ensuring the valve opens. It can be overridden if necessary for stiff, poorly compliant lungs by loosening the screw at the top.

The bag connects to the patient through a one-way valve to direct exhaled air to the atmosphere. The other end connects to the oxygen supply and can attach to a reservoir bag which allows high concentrations of oxygen to be delivered (can be up to 98%). Without the reservoir bag, only concentrations of up to 40% O_2 are delivered. The bag itself is easily dismantled and reassembled. It is important to realize that this system **will operate** without an attached oxygen supply, allowing resuscitation to be initiated before oxygen is available. However, if resuscitation is failing, check that oxygen is being delivered into the bag and to the patient and that the O_2 has not been disconnected.

Always use high flow oxygen and reservoir bag during resuscitation

Clean the system after each patient

Figure Two sizes of self-inflating bag with reservoirs and a selection of masks.

It is essential that the mask is properly sized and correctly placed over the mouth and nose of the patient.

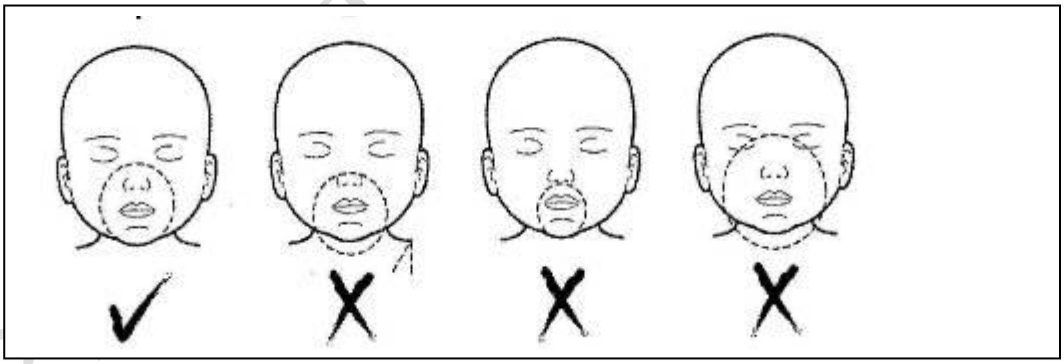


Figure Correct and incorrect mask placement on an infant

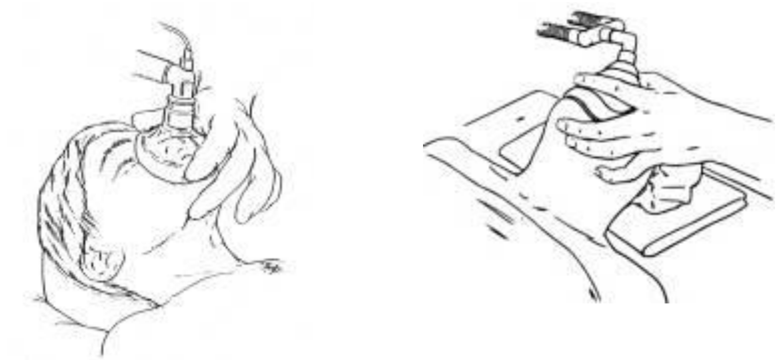


Figure
One-handed hold
For mask

Figure Two-handed hold for mask

If the chest does not rise, then the airway is not clear. The usual cause is failure correctly to apply the airway opening techniques previously discussed. The first step to try is to readjust head tilt / chin lift position and try again. If this is not successful, jaw thrust should be tried. Failure of both head tilt / chin lift and jaw thrust should lead to suspicion that a foreign body is causing the obstruction.

Once breathing restarts, replace bag-valve-mask system with simple face-mask and reservoir. **Because of the internal valves it is not possible to spontaneously breathe through the bag-valve-mask system.**

Chest tubes

In cases with a significant haemothorax or pneumothorax (particularly **tension pneumothorax**), ventilation may be compromised and insertion of a chest drain is mandatory (see below)

Gastric tubes

Insertion of a gastric tube is essential after intubation and may also relieve respiratory distress in spontaneously breathing patients with abdominal emergencies or gastric stasis. It allows decompression of a stomach full with air from both bag and mask ventilation as well as air swallowed by a distressed patient. Without a gastric tube, the patient may vomit or aspirate on stomach contents. In addition venting of stomach gas will avoid diaphragmatic splinting. A nasogastric tube will increase airway resistance through the nose, which in a spontaneously breathing infant in respiratory failure can be significant. An oro-gastric tube has less effect on ventilation but is less easily tolerated and less easily fixed in position.

SECTION 7 QUIZ 1

1. **When using pharyngeal airways the following statements are true:**
   a. a nasopharyngeal airway must NOT be used in a head injury if there is a possibility of a base of skull fracture
   b. an oro-pharyngeal airway is safe in a patient with a gag reflex
   c. a correct size for an oro-pharyngeal airway reaches the angle of the mandible when the flange is at the centre of the incisors
   d. most important is that insertion improves the patient's airway

ANSWERS:

1. acd

SECTION 7 QUIZ 2

1. **When giving additional inspired oxygen the following statements are true:**
   a. 45% oxygen is the highest level that can be achieved with a reservoir
   b. it can be provided by an oxygen concentrator at a flow rate of 1 – 8 l/min
   c. is needed when treating respiratory distress, central cyanosis, shock or grand mal fitting

2. **When using bag valve mask ventilation the following statements are true:**
   a. you should include an oxygen reservoir bag during resuscitation
   b. there is a blow off valve set at 60 cm H_2O
   c. a 1600 ml size is suitable for an infant

ANSWERS:

1. bc 2. a

CIRCULATION: Equipment and skills for maintaining the circulation (IMEESC 13.3 and WHO Pregnancy C-21 and S-3)

Peripheral venous cannulation

Prepare kit:

IV cannula or butterfly needles: 2ml syringe and "T-piece" containing 0.9% sodium chloride for flushing: Tape or plaster of paris for scalp veins: Small splint (can be made from wooden spatula): Swab/spirit for skin cleaning: Local anaesthetic cream if available: Tourniquet (or assistant).

Cannula size: in situations of shock use the largest possible:

neonate 24-25G: infant 22-24G: child 20-22G: pregnant woman or girl 14-20G.

Apply tourniquet to distend vein.

Choose vein:

Useful sites include the dorsum of feet and hands. The saphenous and antecubital veins are larger. The antecubital veins are also useful for venepunctures for laboratory studies.

If possible, place close to bone where more fixed.

Decide direction of blood flow.

Clean skin with antiseptic.

Fix and slightly stretch skin with other hand.

Pass cannula through skin at slight (10-20 degrees) angle-be decisive.

Stop once through skin.

Flatten cannula to skin and advance with long axis of cannula in same direction as vein-be decisive.

Aim to pass into vein at first attempt with steady advancement.

Always watch for blood appearing in hub of cannula. As soon as blood seen stop advancement.

Hold needle still, advance cannula over needle until hub at skin.

Hold cannula still and withdraw needle.

Connect connector, flush and fix. No subcutaneous swelling should be seen and there should be no resistance to injection.

If no blood seen on advancing cannula but felt to be beyond vein, stop and gently pull cannula back in same direction as advancement. If blood appears, stop once again. Follow procedure as if blood seen on first advancement (transfixion technique).

Connect T-piece and flush cannula gently with saline to confirm in vein.

Tape in place by looping thin piece of the tape under the hub and round to form a "V" shape fixing it to skin.

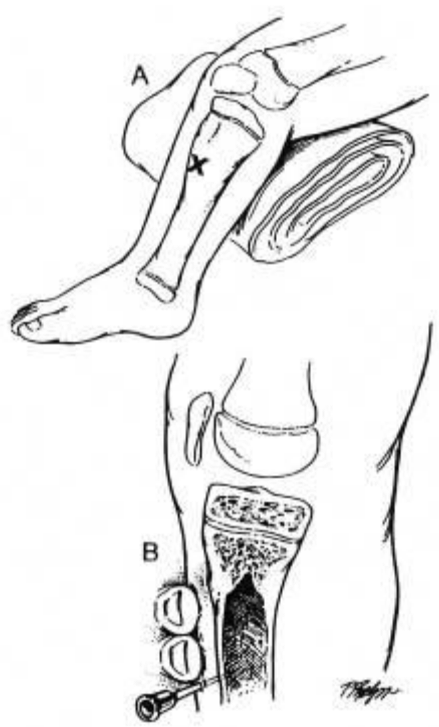
When splinting try to "double back" tape, i.e put a short and a long piece back to back leaving just the ends of longer piece sticky. This helps prevent excessive amounts of tape sticking to the baby, particularly important in more immature babies whose skin is easily damaged.

Note on flushing lines: the smaller the syringe used, the greater the pressure exerted on fluid in line. Therefore avoid using 1ml syringes to flush a blocked line - it may rupture or damage tissue.

Blood sampling from IV cannula

In children, blood can be dripped from end of cannula into appropriate bottles or a syringe and sterile needle can be used to gently aspirate blood from cannula. If cannula has been flushed with saline prior to insertion the first 0.5 - 1 ml of blood should be discarded. Ideally, sample from a separate site.

Intraosseous cannulation and infusion (IMEESC 13.3)



Indication In emergency when other attempts at IV access have failed in an infant, child or pregnant woman or girl.

1. Identify the infusion site. The landmark for the upper tibial site is shown below:

TIBIAL
Anterior surface, 2 - 3 cm below the tibial tuberosity

2. Clean the skin over the chosen site and apply sterile drapes.

3. Insert local anaesthetic (1% lidocaine with fine needle 22-25G) down to periosteum if patient is conscious.
4. Insert the needle at 90° to the skin. Ideally 18G intra-osseous needle (at least 1.5cm in length). In situation of poor resources, a lumbar puncture needle or even standard 16-18 gauge needle can be used. For infants 21G green needles are quite adequate

5. Continued to advance the needle in a rotating fashion until a give is felt as the medullary cavity of the bone is entered. The needle should stand up by itself.

6. Attach the 5 ml syringe and aspirate blood/marrow for as required; cross match, Hb, culture, glucose and then flush with 0.9% saline to expel clots and observe for subcutaneous swelling to confirm correct positioning.

6. Attach the 50 ml syringe, usually containing, 0.9% saline, but can be compatible blood or 10% glucose if hypoglycaemia is suspected, and push in the infusion fluid in boluses.
7. Secure IV access as soon as possible. When needle is removed cover with sterile dressing.
8. Do not place distal to a major fracture or where there is infection.
9. GIVE PROPHYLACTIC ANTIBIOTICS after immediate emergency is managed.

Complications

Dislodgement
Misplacement (penetration through posterior cortex, failure to penetrate cortex producing

- haematoma
- tissue necrosis
- compartment syndrome

Skin infection
Osteomyelitis
Tibial fracture in babies

Useful issues

All drugs and fluids used for treating a sick child can be given.
IV access should be obtained as soon as possible after IO placement so that IO needle can be removed to reduce complication risk.
Measurement of Hb, platelets and wbc counts are inaccurate, but blood group and cross match and blood cultures can be performed.

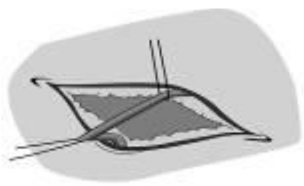
External jugular vein (can be used in all age groups and in pregnancy)

- Place in a 15 to 30° head-down position (or with padding under shoulders so that head hangs lower than shoulders).
- Turn head away from site of puncture. Restrain child as necessary in this position.

- Clean skin.
- Identify external jugular vein, which can be seen passing over sternocleidomastoid muscle at junction of its middle and lower thirds.
- Have an assistant place his or her finger at lower end of visible part of vein just above clavicle. This stabilises it and compresses it so that it remains distended.
- Puncture skin and enter vein.
- When free flow of blood is obtained, ensure no air bubbles are present in tubing and then attach a giving set.
- Tape cannula securely as very easily dislodged.

Cut down long saphenous venous cannulation

Indication: continuous IV access where percutaneous attempts have failed: (in an emergency an infant or child intra-osseous access is faster and easier)



Drawing of long saphenous vein anatomy

Equipment

Skin prep (iodine, alcohol)
Scalpel
Suture
IV cannula
Assistant

Local anaesthetic
Curved artery forceps
Syringe and hypodermic needle
Sterile drapes

Procedure

IMEESC Make a transverse incision two finger breadths superior and two fingers anterior to the medial malleolus. Use the *patient's* finger breadths to define the incision: this is particularly important in the infant or child.

Identify landmarks:-

Infant	Half a fingerbreadth superior and anterior to medial malleolus
Small child	one fingerbreadth superior and anterior to medial malleolus
Older child and pregnant woman or girl	two fingerbreadths superior and anterior to medial malleolus

1. Immobilise limb and apply blood pressure cuff at pressure between venous and arterial
2. Clean skin and drape with sterile towels.

3. Infiltrate local anaesthetic into skin after marking the site of the vein (if conscious).
4. Incise skin perpendicular to long axis of vein.
5. Bluntly dissect subcutaneous tissues with curved artery forceps (tips pointing downwards) parallel to vein. With tips pointing up scoop up tissues and open the forceps- you should have picked up vein. Clear about 2cm of vein from surrounding tissue.
6. If the vein is not collapsed insert the largest possible venous cannula into it as you would if going through the skin. If collapsed proceed as below.
7. Pass a proximal and distal ligature around vein. Tie only distal ligature and use for traction.
8. Make the smallest cut in the vein with a scalpel as possible to take the cannula proximal to the tied ligature and feed catheter into vein proximally (ideally up to the hub). Use the largest cannula possible. Tie proximal ligature around vein and catheter. Alternatively with the needle stylet still inside the catheter, use this to enter the vein.
9. Aspirate blood (if blood does not aspirate you may be against vein wall so pull catheter back a little and repeat) and flush with 0.9% saline.
10. Close incision with interrupted sutures, place antiseptic ointment (eg iodine) over wound, and suture catheter to skin (ensure local anaesthetic at suture site if conscious).
11. **IMEESC** Do not suture the incision close after catheter removal as the catheter is a foreign body. Allow any gap to heal by secondary intention.

SECTION 7 QUIZ 3

1. **When placing an intrasosseous needle the following statements are true:**
   a. in an infant or child can be inserted on the anterior surface of the tibia 2 to 3 cm below the tibial tuberosity
   b. does not need local anaesthetic first if conscious
   c. must be a sterile procedure
   d. blood group and cross match can be obtained from aspirated bone marrow specimen but Hb and platelet counts are inaccurate
   e. can be placed distal to a major fracture

ANSWERS:

1. acd

Needle pericardiocentesis see under Trauma procedures Section 14.

Additional procedures

Emergency Surgical airway: Surgical cricothyroidotomy (IMEESC Best Practice Protocol)

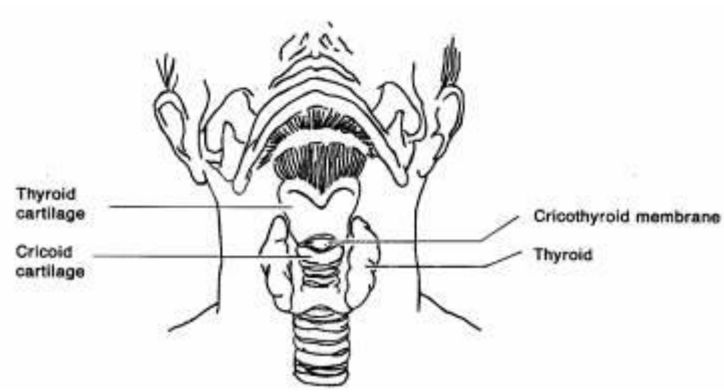
Only in desperate situation if other methods of airway opening procedures have failed

Call surgeon (ENT) and anaesthetist (if available)

1. Place supine.
2. If no risk of neck injury, consider extending neck to improve access. Otherwise, maintain a neutral alignment.
3. Identify cricothyroid membrane in the following manner. Place your finger over the most prominent part of thyroid cartilage (Adam's apple). Move the finger downwards i.e. towards

the chest, keeping strictly in the mid-line. The first dip felt is the area of cricothyroid membrane.

4. Prepare skin and, if patient is conscious, infiltrate with local anaesthetic.



5. Place index and middle fingers of your left hand on each sides of midline of neck to stabilise cricothyroid membrane, and to protect lateral vascular structures from injury.
6. Make a small vertical incision in skin, and with the index and the middle fingers of the left hand, press lateral edges of incision outwards, to minimise bleeding.
7. Make a transverse incision through cricothyroid membrane, being careful not to damage cricoid cartilage.
8. Insert a tracheal spreader to open airway.
9. Insert an appropriately sized endotracheal or tracheostomy tube. It is advisable to use a slightly smaller size than would have been used for oral intubation e.g. size 6.0mm internal diameter for age 12-16years or size 7.0mm for adults.
10. Ventilate patient and check that this is effective – if not and if large air leak after inflating cuff may need to change tube for a size bigger.
11. Secure tube to prevent dislodgement.

IMEESC state that this procedure should not be used in a child under the age of 10 years; passing several needles through the membrane will give enough air entry.

Complications

- Asphyxia: Aspiration of blood or secretions: Haemorrhage or haematoma.
- Creation of a false passage into tissues: Surgical emphysema (subcutaneous or mediastinal).
- Pulmonary barotraumas: Subglottic oedema or stenosis: oesophageal perforation.
- Infection.

Pulse Oximetry (IMEESC 14.6 and 15.2)

How to Apply the Oximeter

1. Switch on the oximeter.
2. Make sure any mains supply is also switched on (this will charge the internal battery, if this exists) - the sensor should light up.
3. Apply the sensor to a relatively translucent part of the body, for example, a finger or toe in a child or adult, or to the side of the foot, the palm, thumb or big toe in an infant.
4. Fix the sensor in position:

- **flexible** sensors should be secured with either their own sticky tape, or additional sticky tape that stretches, so arterial pulsations are not impaired
- rigid sensors, or 'crocodile clips,' usually attach on a finger and do not need further fixation

5. In situations of bright light, or poor skin perfusion, consider covering the sensor further using, for example, a glove, mitten, or sock.
6. Wait for a short period of time, usually 30 seconds, before reading the measurement of SaO2 and heart rate from the oximeter, but only when an adequate arterial (or other) pulsation is found. Most oximeters will have either a bouncing bar display or arterial pulse waveform that is in time with the patients pulse or heart rate.
7. Set the low and high alarm limits for the oxygen saturation (eg 85% and 100%) and pulse rate.
8. Take readings of SaO2 and pulse rate when a good pulsation is present and the values are relatively stable.

Normal Values

- These are usually 95-100% when breathing room air at sea level, and in the presence of good pulse detection.
- Lower levels if breathing or cardiac problems.
- Low levels whilst breathing additional oxygen usually indicate very serious breathing problems.

- Normal levels whilst breathing additional oxygen do not mean that ventilation is normal (may have a significant retention of carbon dioxide).
- May not get accurate reading if patient shivering, moving, if cold hands or feet, wearing nail varnish or if there is carbon monoxide poisoning, as with for example burns.

Note: skin colour, sickle cell disease and other haemoglobin disorders do not significantly affect the measurement of SaO2.

SECTION 7 QUIZ 4

1. When making a surgical airway the following statements are true:

a. It is a desperate measure when other ways of opening the airway have failed
b. can be kept open using an endo-tracheal tube slightly smaller than used for intubation

2. When using a pulse oximeter the following statements are true:

a. normal values are not dependant on altitude
b. accurate readings do not require good quality pulse waveforms
c. readings are inaccurate if carbon monoxide poisoning or when nail varnish is present
d. normal values are 95 – 100% when breathing air at sea level
e. normal levels whilst breathing additional oxygen mean that ventilation is normal

ANSWERS:
1. ab 2. cd (high levels of CO2 representing hypoventilation can be present with normal SaO2 levels)

Spacers and nebulisers

Spacers

- Salbutamol can be delivered using spacer device 2-10 puffs ½-4 hourly.

- 0-3 years use mask and spacer. Take MDI and shake, place in end of spacer, ensure good facial seal (distraction and play are useful to ensure compliance). Press MDI once and ask child to take 5 normal (effective) breaths, press MDI second time and repeat (NB if breaths ineffective request 10 instead of 5 breaths). Shake MDI after each 2 puffs, as if this is not done only propellant will be delivered.
- Assess benefit after 10 puffs (whole process takes 5-10 minutes dependant on compliance).
- This can be repeated every ½ hour. As symptoms improve increase time between treatments to 1 hourly/2 hourly/4 hourly. Usually need to have 10 puffs 4 hourly for 48 hour then 2 puffs as required.
- After 3 years of age the mouth piece of the spacer can be used.
- If patient is requiring O_2 therapy via nasal cannula < 2 litres/minute it can be continued whilst spacer treatment is delivered.

Use of a spacer

- When spacer is new, and also between treatments, it should be washed with warm soapy water and left to dry naturally. Drying by any other means will build up static and encourage the drug to stick on the sides of the spacer rather than be delivered to the patient.
- As child takes a breath with a commercial spacer, a disk will be seen and heard to move back and forth allowing medication to be delivered. If child sleeping and still requiring treatment then the spacer and mask can be used. Place the mask over mouth and nose ensuring good seal. Tilt spacer 40º angle to open valve, medication will be naturally delivered. Ensure 5-10 breaths between puffs.

If there is no proper spacer:

- *A very effective spacer can be made using a plastic IV fluid bottle – see picture or soft drink bottle.*
- *Failing this an effective aid to inhalation is a paper bag. Express salbutamol into the paper bag and place the bag tightly around the nose and mouth of the patient. Have the patient breathe in and out ten times.*

Nebuliser

- Nebulisers can be driven by oxygen or electrically (must deliver at least 6-9 litres/minute). If severe asthma and possible hypoxia, use O2 to drive the nebuliser.
- Need regular cleaning and servicing.
- Equipment required

    Straight O_2 tubing (bubble tubing can be used if this is all that is available)
    Medication chamber
    Mask

Attach tubing to medication chamber, add dose of salbutamol to medication chamber and attach mask.
Switch O_2 on at 8 litres/minute (= best flow for dispersement of medication).
Continuous nebulised treatment can be given until symptoms improve. Then treatments can be reduced 1 hourly/2hourly/4 hourly and then as required to control symptoms. Change to MDI and spacer prior to discharge.
Mask should always be used for <7 years.
>7 year mouthpiece can be attached instead of mask. However this is difficult to use in severe asthma.

- Between treatments medication chamber and mask should be washed with warm soapy water and left to dry naturally.

If there is no nebuliser:
Use a spacer and give salbutamol continuously

SECTION 7 QUIZ 5

1. **When giving salbutamol via a spacer for acute severe asthma the following statements are true:**
   a. 2 – 10 puffs of the MDI can be given ½ to 4 hourly
   b. 5 effective breaths from the spacer are appropriate for each puff of the MDI
   c. it is not necessary to shake the MDI

2. **When giving salbutamol via a nebuliser for acute severe asthma the following statements are true:**
   a. it is safer to use oxygen to drive the nebuliser
   b. a mask can be used for babies and young children
   c. best oxygen flow for dispersing medication is 4 l/minute

ANSWERS:

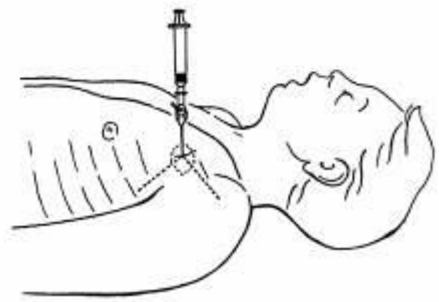
1. ab 2. ab

Needle thoracocentesis (IMEESC 16.3)

When a tension pneumothorax is present this procedure can be life saving. It can be performed quickly with minimum equipment. A confirmatory CXRay is not required or appropriate. It should be followed by chest drain placement.

Procedure for thoracocentesis

- Identify second intercostal space in mid-clavicular line on the side of the pneumothorax (opposite side to the direction of tracheal deviation)
- Swab chest wall with surgical prep
- Attach syringe ideally via a 3 way tap to needle / IV cannula/butterfly
- Insert needle / cannula vertically into chest wall, just above the rib below to avoid vessels, and aspirate
- If air is aspirated, leave cannula in place and proceed to chest drain insertion



Chest drain insertion

This is best performed by an open technique as this minimizes lung damage by avoiding use of the trochar. The largest tube which will pass between the ribs is used.

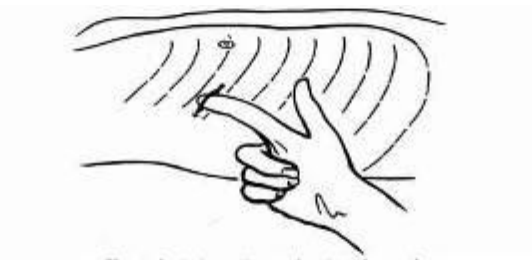
Indications

- Post thoracocentesis
- Simple pneumothorax
- Haemo-pneumothorax

Sites for chest drain

Procedure

- Prepare patient – this must be a fully sterile procedure
- Identify landmarks – 4th or 5th intercostal space, mid-axillary line (4th intercostal space in pregnancy)
- If conscious use local anaesthetic
- Make a 1-3 cm incision immediately above the rib below (to avoid damage to the neurovascular bundle under the lower edge of the rib)
- Use artery forceps for blunt dissection between the ribs and puncture the pleura
- If possible, clear the path with a gloved finger (not possible in babies / small children)
- Hold about 1 cm from end and pass the chest drain through the hole and ensure all side holes are within the chest
- Connect to underwater seal or Heimlich valve
- Check the tube is in place (misting should occur and air entry should improve)
- Suture tube in place - make sure the area is anaesthetised
- Cover wound and get CXR if possible
- Check the patient has improved
- Ensure water level is always below the chest to prevent water leaking back into the chest
- **IMEESC** Suture tube in place - make sure the area is anaesthetized. Leave an additional suture untied adjacent to the tube for closing the wound after the tube is removed



Chest drain insertion - clearing the path

If there is no Heimlich valve?
One can be made using the finger of a sterile surgical glove.

Complications of chest drains

1. Failure to position properly
2. Infection
3. Surgical (subcutaneous) emphysema
4. Haemorrhage
5. Damage to internal thoracic artery if drain is placed too medially
6. Damage to intrathoracic or abdominal structures
7. Kinking of chest tube or obstruction by blood clot

ALWAYS CLAMP THE TUBE WHEN MOVING THE PATIENT

SECTION 7 QUIZ 6

1. When treating a tension pneumothorax the following statements are true:
   a. a chest x-ray is required before needle thoracocentesis
   b. the landmark for needle thoracocentesis is the 2nd intercostal space, mid-clavicular line on the side of the pneumothorax
   c. does not need to be an aseptic technique
   d. if air is aspirated proceed to chest drain

2. When placing a chest drain the following statements are true:
   a. use a trochar to pass tube between ribs
   b. the landmark in pregnancy is the 5th intercostal space in the mid-axillary line
   c. requires local anaesthetic if conscious

ANSWERS:
1. bd 2. c (a trochar may cause serious damage)

Measuring Blood glucose

Blood can be used from: samples taken for malarial screen etc – don't remove from bottle containing EDTA. Only require one drop

Capillary sample
- Source needs to be warm and well-perfused.
- Area needs to be clean (sugar free!) – but make sure alcohol has evaporated as this can confuse results.
- Using Vaseline (petroleum jelly) rubbed over skin makes drops easier to collect.
- Suitable areas include finger pulp and earlobes (sides of heels in neonate).
- If available use lancet/"tender-touch" etc. If an ordinary needle is used puncture skin at angle of 45 degrees to avoid unnecessarily deep wound.
- Squeeze GENTLY to gain drop.
- If using "BMstix" or "Dextrostix" check they have not expired, are dry and not discoloured. You can use one stick for more than one test if it is cut lengthways before use. Cover indicator mark with drop (do not smear). Wait one minute before wiping off drop and reading against the colour chart on tube.
- For Neonates readings are not reliable below 5 – if any doubt, treat as hypoglycaemia. Generally, hyperglycaemia if >10 and **hypoglycaemia if < 2.5 mmol/litre (45mg/dl).**
- Normal values – 3.3 - 5.5 mmol/l (63-99 mg/dl).

Lumbar puncture

Dangerous in the presence of raised intra-cranial pressure

Beware if blood clotting disorder (eg. platelets <80 x 10^9/litre).

Excessive neck flexion when positioning can lead to hypoxaemia and acute respiratory deterioration.

If spinal needle is unavailable and a normal (non-stylet) needle is used, the needle bore may become blocked with skin on insertion and hence not flow. There is also risk of tissue implantation leading to dermoid cyst.

Advance needle slowly. Subarachnoid space is only 0.5 to 0.7 cm below skin in premature infants and 1 cm in babies; hence over-penetration is an easy mistake. Over-penetration leads to puncturing of anterior vertebral venous plexus and a bloody sample, so that CSF microscopy is less informative or impossible.

Equipment

Skin prep, sterile gloves, sterile dressings pack, spinal needle with stylet (in poorly resourced healthcare facilities an ordinary 18-22 gauge needle may be used), small sterile dressing.

Figure Positioning for lumbar puncture

Indications

- To diagnose meningitis.
- As part of a septic screen (especially in infants).

Procedure

- Full surgical asepsis must be undertaken.
- Position patient on the edge of the examination table in lateral decubitus or sitting up. An experienced assistant to hold patient is helpful. Flex spine maximally whilst avoiding excessive neck flexion.
- Clean the lumbar area with skin prep. Drape with sterile towels.
- Identify site of insertion: L4 to L5 lumbar space (on level with iliac crests).
- Slowly insert spinal needle in midline, aiming towards umbilicus.
- Stop advancing when "give"/puncture sensation is felt on entering subarachnoid space (often not felt in neonates). May have to do frequent stylet withdrawals during procedure to see if CSF flows, this is to ensure that subarachnoid space has been successfully entered.
- Withdraw stylet. Allow 6 drops of CSF to drip into each sample container.
- Replace stylet.
- Withdraw needle and swab puncture site with skin prep.

- Cover site with sterile dressing.
- Send samples for
  - microbiology (gram stain, mycobacterium culture if suspected, microscopy, cell counts, culture and sensitivity).
  - glucose and protein.

Gastric tube insertion (IMEESC 14.7)

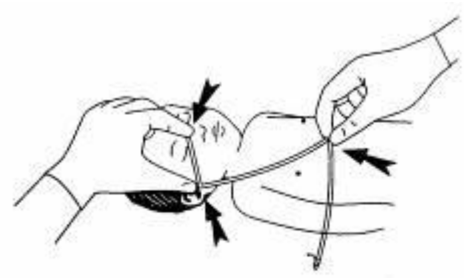
Equipment

Syringe: Gastric tube: Lubricant (KY jelly or clean water): Stethoscope.

Litmus paper: Adhesive tape.

Procedure

- Place supine with head in 'sniffing' position.



Measure length of tube-from nose or mouth via earlobe to mid-point between xiphoid and umbilicus.

Feed tube lubricated with KY jelly or 0.9% Saline through either nose or mouth directly backwards. (The neonate is a nose breather and therefore the oral route is preferred). Try to advance tube as patient swallows. If infant has respiratory distress, oro- gastric tube is best. If passed through nose increases upper airway resistance.

Check position of tube by aspirating stomach contents and checking a change in the litmus paper (blue to pink), or flush the tube with 2 to 3ml air (only 1ml in neonate) and listen over stomach. If in doubt Xray chest/abdomen. NB: acidity of gastric fluid may be reduced in preterm infants

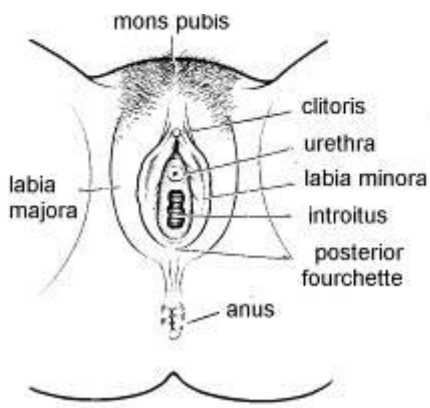
Secure the tube by taping it to cheek and record length of tube outside nose or mouth.

Urethral Catheterisation (IMEESC Best Practice Protocol and section 9 and WHO Pregnancy C-48)

Indications:

- To collect sample (eg infant – can be removed once sample obtained)
- Where no spontaneous urine output
- If continuous urine output measurement is required

Caution: Signs of urethral damage should be excluded first before urethral catheterization (eg blood at external meatus or bruising to the scrotum or perineum). If any doubt, or in cases of abdominal / pelvic injury, decision to catheterize must be decision of surgeon.



Methods:

Use appropriate size of catheter i. e. one that is smaller in diameter than the external urethral meatus (risk of subsequent urethral stricture formation). Sterile NGT can also be used – there is a risk of it falling out, but with critically ill child this is adequate if taped to penis and medial aspect of thigh and

patient nursed carefully. Do not attempt to use a tube larger than the meatus.
If male patient conscious (esp older children) use lidocaine gel if available. Lubricants should be used even in unconscious patients.
Use sterile precautions (gloves etc), wash area, have sterile pot to hand to take sample, large syringe or catheter bag if available, syringe of water to inflate balloon if is Foley balloon catheter and an assistant to hold legs away
With male hold glans penis securely; there is no need to try and retract foreskin for child less than 3 years. No need for force. Catheter is in sufficiently far when urine is seen in tube.

Rectal Administration of Drugs

In conscious patient explain what you are going to do – it should not be painful. Need consent from an older child.
In most situations rectal quills will not be available so a large NGT cut to about 7 cm, attached to syringe, can be used.
Patients should be on their side with legs bent ("fetal position") – ask the pregnant woman or girl or an assistant to help hold patient in that position.
If KY jelly etc available place on index finger of gloved hand, open anal margin gently and cut end of NGT, advance tube as far as possible, inject drug whilst holding buttocks together.
Keeping plunger of syringe advanced withdraw the syringe and NGT whilst keeping buttocks together.

Continue holding buttocks together for 2 minutes more

SECTION 7 QUIZ 7

1. **When measuring blood glucose the following statements are true:**
   a. Hypoglycaemia = 2.5 mmol/l or less
   b. Hyperglycaemia = 10 mmol/l or more
   c. Normal values are 3.3 – 5.5 mmol/l

2. **A lumbar puncture is contraindicated if the following are present:**
   a. blood clotting is prolonged and/or a platelet count is less than 80 x 10^9/ litre
   b. there is raised intracranial pressure
   c. there is a high fever > 39° C

3. **When placing a gastric tube the following statements are true:**
   a. in the neonate a nasogastric is preferred to an oro-gastric tube
   b. if in doubt as to its position perform x-ray chest/abdomen
   c. length can be estimated as from nose/mouth to ear lobe and then to midpoint between xiphoid and umbilicus

ANSWERS:

1. abc 2. ab 3. bc

Management of cardiac arrest

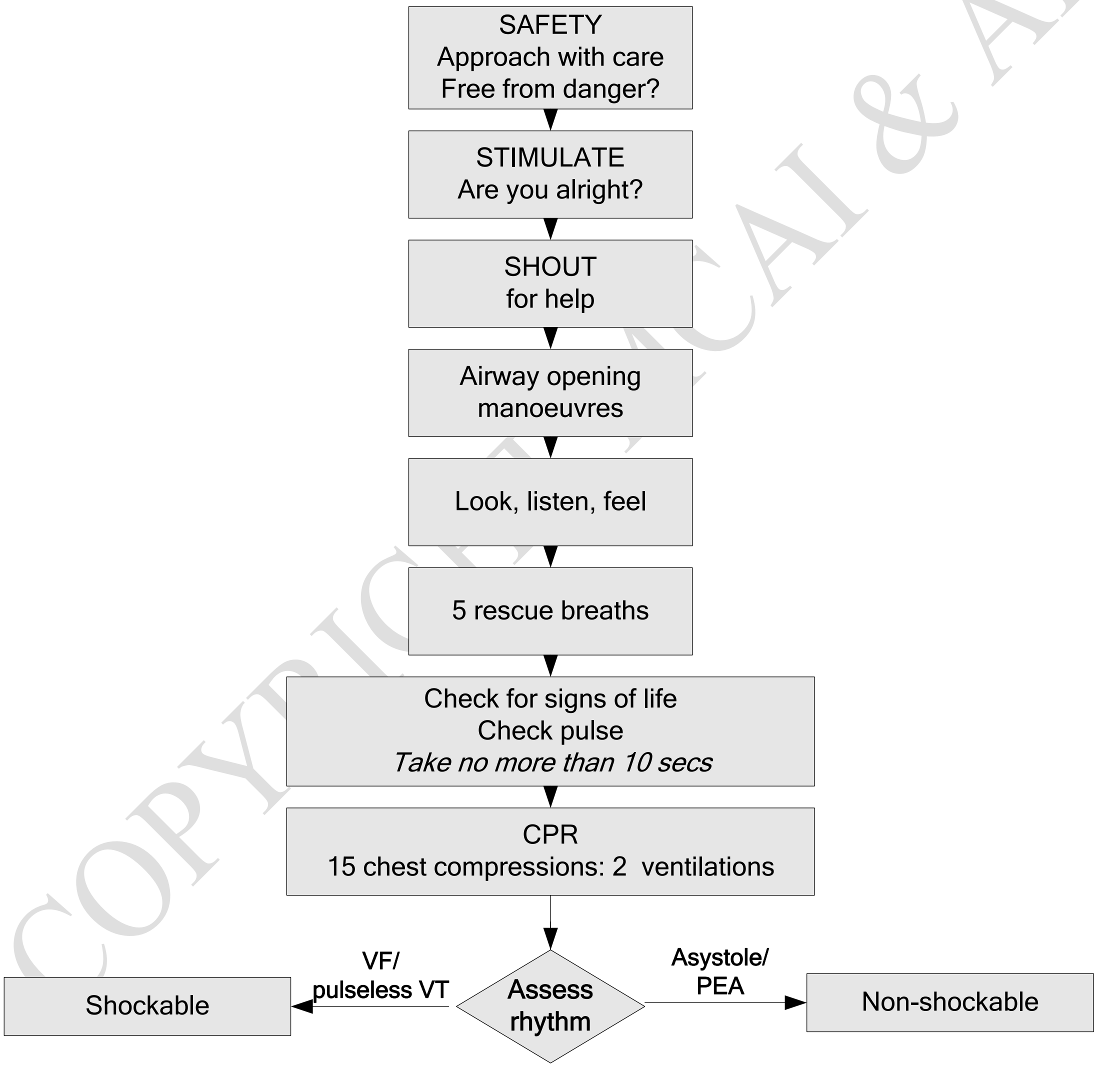
Cardiac arrest has occurred when there is no effective cardiac output. Before any specific therapy is started effective basic life support must be established.

Four cardiac arrest rhythms can occur:

1. Asystole
2. Pulseless electrical activity (including electro mechanical dissociation)
3. Ventricular fibrillation
4 Pulseless ventricular tachycardia

The four are divided into two groups: two that do not require defibrillation (called “non-shockable”) and two that do require defibrillation (“shockable”).

Figure Initial approach to cardiac arrest



Non-shockable cardiac arrest (asystole and pulseless electrical activity).

Asystole

This is the most common cardiac arrest rhythm in infants and children and in pregnancy. The response of the heart to prolonged severe hypoxia and shock (which are the usual pathologies in these groups) is progressive bradycardia leading to asystole.

The ECG will distinguish asystole from ventricular fibrillation, ventricular tachycardia and pulseless electrical activity. The ECG appearance of ventricular asystole is an almost straight line; occasionally P-waves are seen. Check that the appearance is not caused by an artifact e.g. a loose wire or disconnected electrode. Turn up the gain on the ECG monitor.

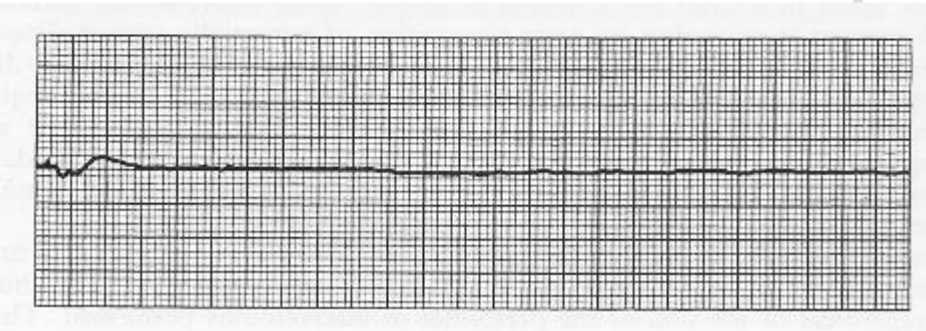


Figure ECG appearance of asystole

Pulseless Electrical Activity (PEA)

This is the absence of a palpable pulse or other signs of life despite the presence on the ECG monitor of recognisable complexes which normally produce a pulse. PEA is treated in the same way as asystole and is often a pre-asystolic state.

PEA in children and in pregnancy is often due to major trauma with often an identifiable and reversible cause such as severe hypovolaemia, tension pneumothorax or pericardial tamponade. PEA is also seen in hypothermic patients and in patients with electrolyte abnormalities. It may be seen after massive pulmonary thromboembolus.

Figure PEA in a child with no pulse or signs of life

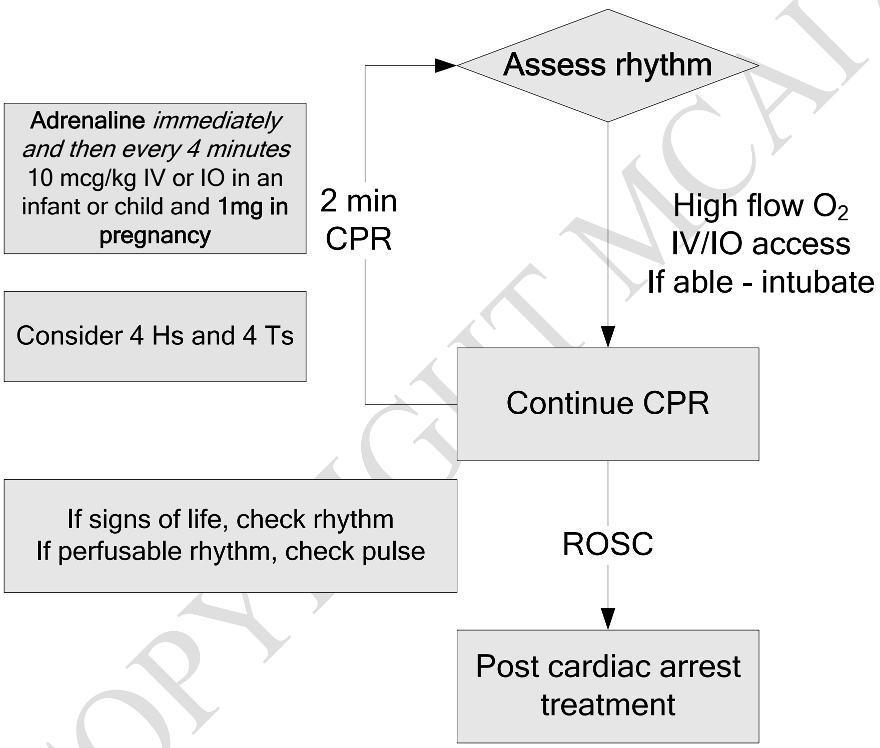
Non- shockable cardiac arrest: management of Asystole/PEA in children and in pregnancy.

The first essential step is to establish ventilations and chest compressions effectively. Ensure a patent airway, initially using an airway maneuver to open the airway and stabilising it with an airway adjunct. Ventilations are provided initially by bag and mask with high concentration oxygen.

Provide effective chest compressions at a rate of 100 to 120 per minute with a compression/ ventilation ratio of 15: 2. The depth of compression should be at least one third of the antero-posterior diameter of the chest. Ideally a cardiac monitor is attached. Properly performed Basic Life Support is key to any chance of successful resuscitation from cardiac arrest. Ensure that the person giving chest compressions is keeping the correct rate and depth of compression and change operator every two to three minutes, if possible, to avoid fatigue causing poor performance.

If asystole or PEA is identified give **adrenaline 10 micrograms per kilogram** (0.1 ml of 1:10,000 solution/Kg) **intravenously or intra-osseously in a child and 1mg IV in pregnancy.** Adrenaline increases coronary artery perfusion, enhances the contractile state of the heart and stimulates spontaneous contractions. The drug is best given through a central line but if one is not in place it may be given through a peripheral line. Where there is no existing IV access, the IO route is recommended as the route of choice as it is rapid and effective. In each case, the adrenaline is followed by a normal saline flush (2 to 5 mls).

If available, and as soon as is feasible, a skilled and experienced operator should **intubate the patient's airway.** This will both control and protect the airway and enable chest compressions to be given continuously, thus improving coronary perfusion. Once the patient has been intubated and compressions are uninterrupted, the ventilation rate should be 10-12 per minute. It is important for the team leader to assess that the ventilations remain adequate when chest compressions are continuous.



ROSC = Return Of Spontaneous Circulation

Figure Algorithm for Asystole/PEA

During and following adrenaline, chest compressions and ventilations should continue. It is vital that chest compressions and ventilations continue uninterrupted during advanced life support as they form the basis of the resuscitative effort. The only reason to interrupt compressions and ventilation is to shock the patient if needed (see below) and to check the rhythm. It may be necessary to briefly interrupt during difficult intubation. Giving chest compressions is tiring for the operator so if enough personnel are available, change the operator frequently and ensure that they are achieving the recommended rate of 100-120 compressions per minute together with a depression of the chest wall by at least one third of the antero-posterior diameter of the chest.

At intervals of about 2 minutes, briefly pause in the delivery of chest compressions to assess the rhythm on the monitor. If asystole remains, continue CPR while again checking the electrode position and contact. If there is an organised rhythm, check for a pulse and signs of life. If there is a return of spontaneous circulation (ROSC), continue post-resuscitation care increasing ventilations to 12-20 breaths per minute. If there is no pulse and no signs of life, continue the protocol. Give adrenaline about every 4 minutes at a dose of 10 micrograms per kilogram IV/IO in a child and 1mg IV in a pregnant woman or girl.

In pregnancy if there is asystole or a slow heart rate < 60 per minute, give atropine 3mg IV just once to counteract any excessive vagal tone.

Reversible causes

The causes of cardiac arrest in childhood and pregnancy are multifactorial but the two commonest final pathways are through hypoxia and hypovolaemia.

All reversible factors are conveniently remembered as the **4Hs and 4Ts** (see below). Sometimes cardiac arrest is due to an identifiable and reversible cause, such as shock from massive haemorrhage. In the trauma setting, cardiac arrest may be caused by severe hypovolaemia, tension pneumothorax and pericardial tamponade.

It is often appropriate to give an early IV bolus of Ringer-Lactate or Hartmann's (10 mls/kg in a child and 500ml to 1 litre in a pregnant woman or girl - depending on her weight) as this will be supportive in cases related to severe hypovolaemia. In addition, however, a tension pneumothorax and/or pericardial tamponade require definitive treatment. Continuing blood replacement and the stopping of haemorrhage may also be required.

Rapid identification and treatment of reversible causes such as hypovolaemic shock, hypothermia, electrolyte and acid-base disturbance, tension pneumothorax and pericardial tamponade are vital.

Continually, during CPR, consider and correct reversible causes of the cardiac arrest based on the history of the event and any clues that are found during resuscitation.

The 4Hs and 4Ts

1. **Hypoxia** is a prime cause of cardiac arrest in childhood and its reversal is key to successful resuscitation.
2. **Hypovolaemia** may be significant in arrests associated with trauma, gastroenteritis, pregnancy related haemorrhage, anaphylaxis and sepsis and requires infusion of crystalloid and, if haemorrhage, give blood.
3. **Hyperkalaemia, hypokalaemia, hypocalcaemia, acidaemia, hypermagnaesemia (following excess magnesium sulphate in eclampsia)** and other metabolic abnormalities may be suggested by the patient's underlying condition (e.g. renal failure or eclampsia), tests taken during the resuscitation or clues given in the ECG (see figures). Intravenous calcium (0.2 mls/kg of 10% calcium gluconate in a child and 10ml of 10% in pregnancy) is indicated in magnesium overdose, hyperkalaemia and hypocalcaemia.
4. **Hypothermia** is associated with drowning incidents and requires particular care and a low reading thermometer must be used to detect it.

1. Tension pneumothorax and
2. **cardiac Tamponade** are especially associated with PEA and are often found in trauma cases.
3. Toxic substances, either as a result of accidental or deliberate overdose or from a iatrogenic mistake, may require specific antidotes.
4. Thromboembolic phenomena (pulmonary or amniotic fluid) in pregnancy.

Shockable cardiac arrest: Ventricular Fibrillation and Pulseless Ventricular Tachycardia

These arrhythmias are less common in children and in pregnancy but either may be expected in sudden collapse, those suffering from hypothermia, poisoning by tricyclic antidepressants and with cardiac disease. The protocol for ventricular fibrillation (VF) and pulseless ventricular tachycardia (pVT) is the same and is shown in Figure X.x

.A sudden witnessed collapse is also suggestive of a VF/pVT episode.

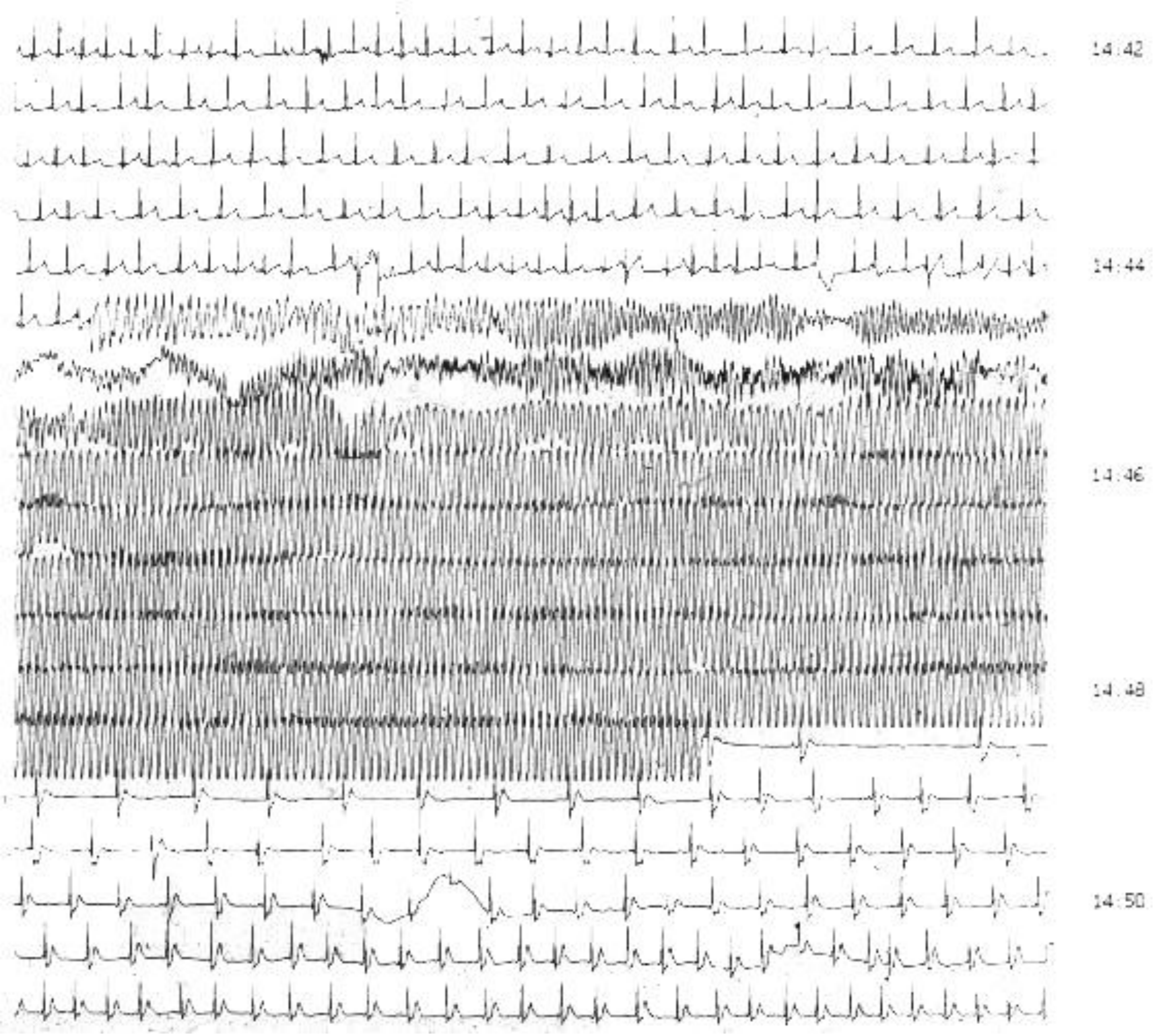


Figure An episode of ventricular fibrillation

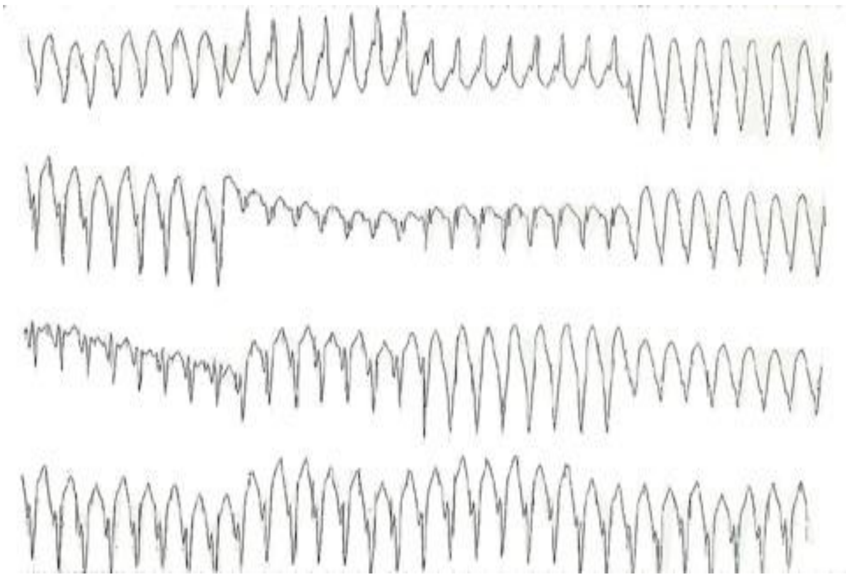
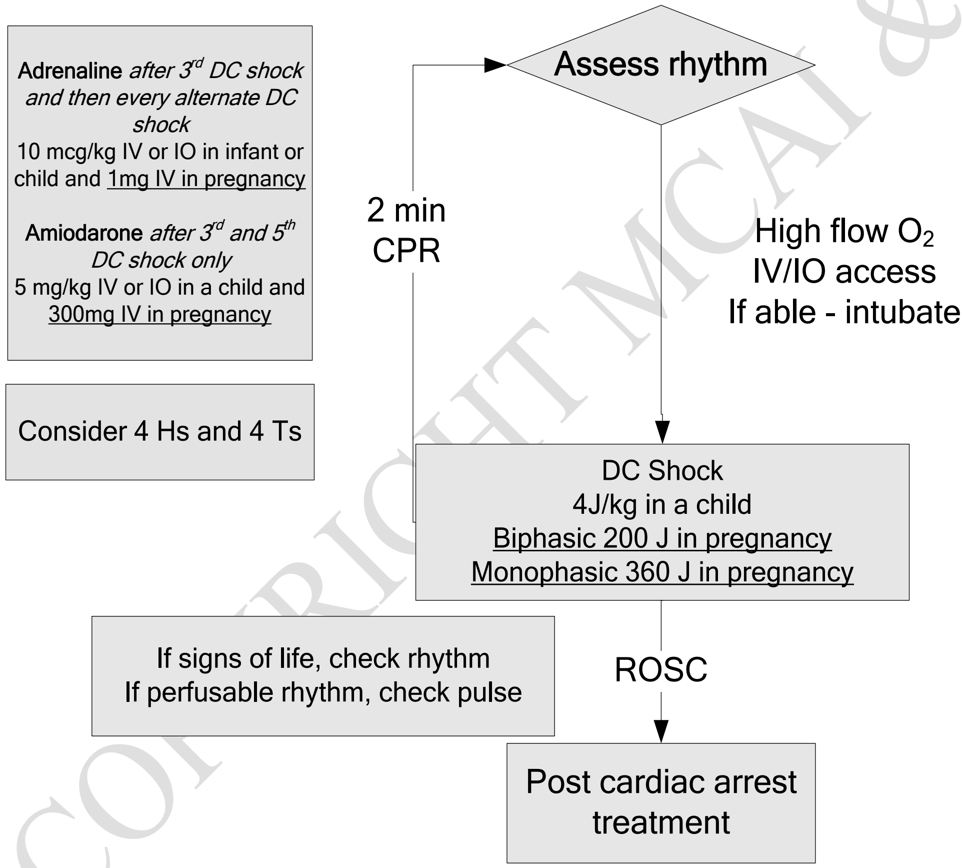


Figure Ventricular tachycardia



ROSC = Return Of Spontaneous Circulation

Figure Algorithm for treatment of VF and pVT

If the patient is being monitored, the rhythm can be identified before significant deterioration. With immediate identification of VF/pulseless VT, asynchronous electrical defibrillation of 4 joules per kilogram in a child and 200 joules (if biphasic defibrillator, 360 joules if monophasic) in pregnancy should be carried out immediately and the protocol continued as above.

In un-monitored patients BLS will have been started in response to the collapse and the identification of VF/pulseless VT will occur when the cardiac monitor is put in place.

An **asynchronous shock of 4 joules per kilogram in a child and 200 joules in pregnancy** should be given immediately and **CPR immediately resumed** without reassessing the rhythm or feeling for a pulse. Immediate resumption of CPR is vital because there is a pause between successful defibrillation and the appearance of a rhythm on the monitor. Cessation of chest compressions will reduce the chance of a successful outcome if a further shock is needed. No harm accrues from "unnecessary" compressions.

Paediatric paddles (4.5 cm) should be used for children under 10 kg.

One electrode is placed over the apex in the mid axillary line, whilst the other is put immediately below the clavicle just to the right of the sternum. If paddles are too large, one should be placed on the upper back, below the left scapula and the other on the front, to the left of the sternum.

Automated External Defibrillators (AEDs) are now commonplace. The standard adult shock is used for children over 8 years. For children under 8 years attenuated paediatric paddles should be used with the AED (if available).

For the infant of less than one year, a manual defibrillator which can be adjusted to give the correct shock is recommended. However, if an AED is the only defibrillator available, its use should be considered, preferably with paediatric attenuation pads. The order of decreasing preference for defibrillation in the under ones is as follows:

1) Manual defibrillator
2) AED with dose attenuator
3) AED without dose attenuator

Many AEDs can detect VF/VT in children of all ages and differentiate "shockable" from non-shockable" rhythms with a high degree of sensitivity and specificity.

If the shock fails to defibrillate, attention must revert to supporting coronary and cerebral perfusion as in asystole. Although the procedures to stabilise the airway and gain circulatory access are now described sequentially, they should be undertaken simultaneously under the direction of a resuscitation team leader.

The airway should be secured, the patient **ventilated** with high flow oxygen and **effective chest compressions** continued at a rate of 100-120 per minute, a compression depth of at least one third of the antero-posterior diameter of the chest and a ratio of 15 compressions to 2 ventilations. As soon as is feasible, a skilled and experienced operator should **intubate the child's airway.** This will both control and protect the airway and enable chest compressions to be given continuously, thus improving coronary perfusion. Once the patient has been intubated and compressions are uninterrupted, the ventilation rate should be 10-12 per minute. It is important for the team leader to assess that the ventilations remain adequate when chest compressions are continuous. **Gain circulatory access.** Whenever venous access is not readily attainable, intraosseous access should be considered early in children as it is rapid and effective. Central venous lines provide more secure long-term access, but compared to IO or peripheral iv access, offer no advantages. In each case any drug is followed by a normal saline flush (2-5 mls).

Two minutes after the first shock, pause chest compressions briefly to check the monitor. If VF/VT is still present, give a **second shock** and **immediately resume CPR** commencing with chest compressions

Consider and correct reversible causes (4Hs and 4Ts) while continuing CPR for a further 2 minutes.

Pause briefly to check the monitor.

If the rhythm is still VF/VT give a **third shock.**

Once chest compressions have resumed give **adrenaline 10 micrograms/kg in a child and 1mg in pregnancy IV** and **amiodarone 5mg/kg in a child or 300mg in pregnancy** intravenously or intraosseously flushing after each drug.

After completion of the 2 minutes of CPR, pause briefly to check the monitor and if the rhythm is still VF/VT give an immediate **fourth shock** and **resume CPR.**

After a further 2 minutes of CPR, pause briefly to check the monitor and if the rhythm is still shockable, give an immediate **fifth shock.**

Once chest compressions have resumed give a second dose of **adrenaline 10 micrograms/kg in a child or 1mg in pregnancy** and a second dose of **amiodarone 5mg/kg in a child or <u>300mg in pregnancy</u>** intravenously or intraosseously.

After completion of the 2 minutes of CPR pause briefly before the next shock to check the monitor. Continue giving shocks every 2 minutes, minimising the pauses in CPR as much as possible. Give adrenaline after every **alternate** shock that is every 4 minutes and continue to seek and treat reversible causes

Note: After each 2 minutes of uninterrupted CPR, pause briefly to assess the rhythm on the monitor.

In addition, if at any time there are signs of life, such as regular respiratory effort, coughing, eye opening stop CPR and check the monitor:

- If still VF/VT, continue with the sequence as above
- If asystole, change to the asystole/PEA sequence
- If organised electrical activity is seen, check for signs of life and a pulse, if there is ROSC, continue post resuscitation care. If there is no pulse (or a pulse below 60 beats per minute) and no other signs of life continue the asystole/PEA sequence

In VT or VF which does not respond to the above and where there is no evidence of previous administration of magnesium for eclampsia, consider magnesium sulphate 25-50mg/kg maximum of 2grams in a child and **<u>8mmol IV bolus (4ml of 50%) in pregnancy</u>.**

Amiodarone
Amiodarone is the treatment of choice in shock resistant ventricular fibrillation and pulseless ventricular tachycardia. The dose of amiodarone for VF/pulseless VT is 5 mg/kg via rapid IV/IO bolus in a child and **<u>300mg IV in pregnancy</u>**.

Lidocaine is an alternative to amiodarone if the latter is unavailable. **The dose is 1 mg/kg IV or IO in a child and <u>100mg in pregnancy</u> as an IV bolus.**

It is DC shock that converts the heart back to a perfusing rhythm not the drug. The purpose of the anti-arrhythmic drug is to stabilise the converted rhythm and the purpose of adrenaline is to improve myocardial oxygenation by increasing coronary perfusion pressure adrenaline also increases the intensity of ventricular fibrillation which increases the success of defibrillation.

Precordial Thump

A precordial thump may be given in monitored patients in whom the onset of VT or VF is witnessed, there are several clinicians present and if the defibrillator is not immediately to hand. However, it is rarely effective and early activation of emergency services and getting an AED is more appropriate; start CPR as soon as possible

Drugs used in Cardiac Arrest (non-shockable and shockable)

Oxygen use

While 100% oxygen must be used during the resuscitation process, once there is return of spontaneous circulation (ROSC) there can be detriment to recovering tissues from hyperoxia. Pulse oximetry should be used to monitor and adjust for oxygen requirement after a successful resuscitation. Saturations should be maintained between 94 and 98 per cent. **Always ensure that oxygen is discontinued during defibrillation shocks to avoid risks of explosions and fire.**

Adrenaline is the first line drug for cardiac arrest

The initial IV or IO dose is 10 micrograms/kg (0.1 ml/kg of 1:10,000 solution) in a child and 1mg (1ml of 1 in 1000 solution) in pregnancy. In the child with no existing IV access, the intraosseous route is recommended as the route of choice as it is rapid and effective. In each case adrenaline is followed by a 0.9% saline flush (2 to 5mls).

Sodium bicarbonate
Good basic life support is more effective than alkalizing agents, which may be considered if spontaneous circulation has not returned after the first or second dose of adrenaline. It is recommended in the treatment of patients with VT/VF due to hyperkalaemia and tricyclic antidepressant overdose (see above).

The dose is 1 mmol/kg in a child (1 ml/kg of an 8.4% solution or 2ml/kg of 4.2% solution) or 50mmol in a pregnant woman or girl.

- Bicarbonate must not be given in the same intravenous line as calcium because precipitation will occur.
- Sodium bicarbonate inactivates adrenaline and dopamine and therefore the line must be flushed with saline if these drugs are subsequently given.
- **Bicarbonate must not be given by the intra-tracheal route.**

If VF/VT is due to tricyclic anti-depressant overdose or hyperkalaemia, this drug may be helpful. In a child give 1mmol/Kg (1ml/Kg of an 8.4% solution or 2ml/Kg of 4.2% solution and in pregnancy give 50mmol.

Hypoglycaemia (less than 2.5 mmol/litre (45mg/dl)

All patients, especially infants and pre-school age children, can become hypoglycaemia when seriously ill. Blood glucose should be checked frequently and **hypoglycaemia must be corrected**. If suspected and blood glucose cannot be measured always give 5ml/kg 10% glucose in a child or 100 ml of 25% glucose in a pregnant woman or girl, preferably IV if not enterally (gastric tube). If blood glucose levels can be measured then avoid hyperglycaemia (blood glucose >12mmol/l).

When to stop resuscitation *(local guidelines should be in place)*

Resuscitation efforts are unlikely to be successful, and cessation can be considered if there is no return of spontaneous circulation at any time after 20 minutes of life support and in the absence of recurring or refractory VF/VT. Exceptions are patients with a history of poisoning or a primary hypothermic insult where prolonged attempts may occasionally be successful. Prolonged external cardiac compressions during which central (femoral or arterial) pulses were felt has successfully resuscitated patients with tricyclic antidepressant overdoses.

The presence of parents at the child's side during resuscitation enables parents to gain a realistic understanding of the efforts made to save their child's life. In general, family members should be offered the opportunity to be present during the resuscitation of their child.

Important points:

A staff member (if available) must be designated to be the parents support and interpreter of events at all times

The team leader, not the parents, decides when it is appropriate to stop the resuscitation.

If the presence of the parents is impeding the progress of the resuscitation, they should sensitively be asked to leave.

The team needs a debriefing session to support staff and reflect on practice

SECTION 7 QUIZ 8

1. **In cardiac arrest (absence of an effective circulation) the following statements are true:**
   a. in the trauma setting may have resulted from severe hypovolaemia, tension pneumothorax and pericardial tamponade
   b. is not caused by hypothermia or electrolyte disturbances or severe acid base disorders
   c. the first line drug is IV or IO adrenaline
   d. an IV fluid bolus should be given where hypovolaemia is a possibility
   e. if the cause is time limited, prolonged cardiac compressions may be effective (e.g. tricyclic poisoning)

ANSWERS:

1. acde

Cardiac arrest and cardiopulmonary resuscitation in the obstetric patient

Background

Cardiac arrest in late pregnancy or during delivery is rare and maternal survival is very low (3-33% in published series). The cause of the arrest is not often reversed and the physiologic changes present in late pregnancy hinder effective CPR.

Cardiac arrest in the pregnant woman or girl results in absent uterine perfusion and the fetus will also die. Even when CPR is ideal, it is not possible to generate a cardiac output of more than 30%.

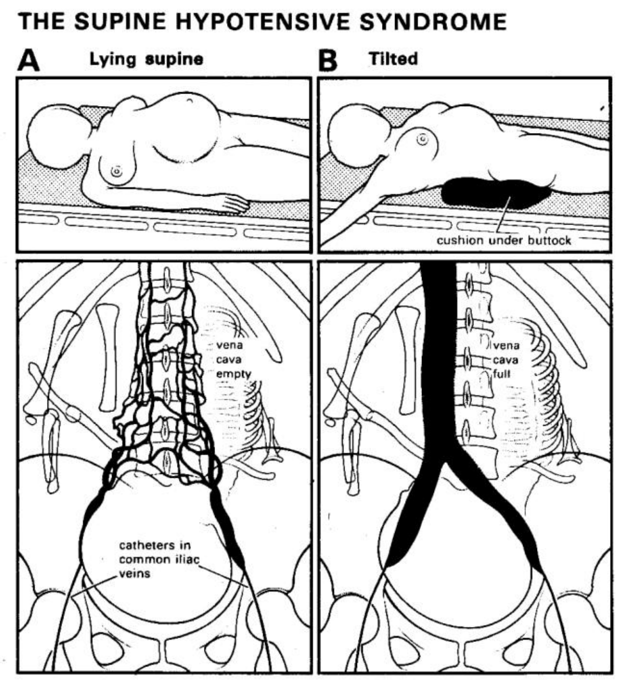
Causes include

1. Massive haemorrhage
2. Pulmonary embolism
3. Trauma
4. Amniotic fluid embolism
5. Severe infection
6. Local anaesthetic toxicity

Physiologic changes of pregnancy as they relate to cardiopulmonary resuscitation

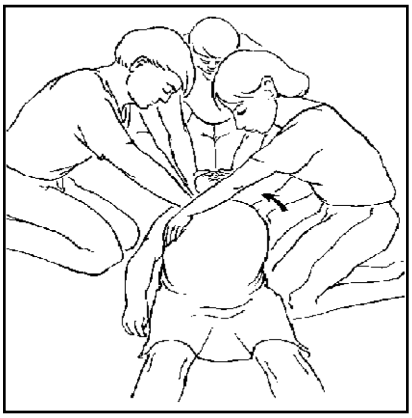
- Pregnant women or girls more easily develop hypoxaemia.
- The enlarged uterus along with the resultant upward displacement of the abdominal viscera decreases lung compliance.
- The most serious is aorto-caval compression in the supine position. **It is essential that CPR is performed in the left lateral position in any pregnant woman where the uterus is a significant intra-abdominal mass (usually after 20 weeks gestation).** During closed-chest cardiac compression the best cardiac output that can be achieved is between one-fourth to one-third of normal. Although many factors contribute to this, poor venous return to the heart is of paramount importance. At term the vena cava is completely occluded in 90 percent of supine pregnant patients. This results in a decrease in cardiac stroke volume of as much as 70%. **It may also be helpful manually to displace the uterus to the left in advanced pregnancy (see Figure).**
- CS early in resuscitation vastly improves the effectiveness of maternal resuscitation.

Left lateral tilt



THE SUPINE HYPOTENSIVE SYNDROME. These are both venograms. A, the mother is lying on her back, her uterus is occluding her vena cava, and all the blood from the lower part of her body is flowing through her paravertebral veins. B, a pillow has now been put under her right buttock tilting her to the left. Blood is now flowing normally in her vena cava. *Kindly contributed by Murray Carmichael.*

Manually displacing a large uterus to the left to aid in CPR



Peri-mortem Caesarean section (CS)

- CS should be performed as soon as possible. This will immediately relieve the vena caval obstruction and increase the chance of survival for both infant and pregnant woman or girl. CPR must be continued throughout the procedure until spontaneous and effective cardiac activity occurs.
- Assisted ventilation may have to be continued for a longer period of time. Some infants have survived when delivered after 20 minutes of maternal resuscitation.
- Without CS <10% arresting in hospital will survive to discharge. Removal of the infant improves maternal circulation during resuscitation – cardiac output immediately increases 20 – 25%.

Perform the CS with a midline vertical incision, or whatever the operator is most used to doing, and remove the baby as fast as possible. Remove lateral tilt when baby is delivered.