Section 1 Resuscitation of the newborn Infant

Introductory issues

The mother's needs come first if you are on your own. Most infants are quite good at looking after themselves, once they are breathing and wrapped. If possible, keep all newborn infants with their mothers. Remember that parents need to be told what is happening to their newborn child.

When to cut and clamp the cord in an infant who needs resuscitation at birth
There are advantages to delaying clamping of the cord for 1 to 2 minutes after birth to allow placental transfer of blood to the infant (see Section 2). However, it is important to ensure that by doing this there is no harm to the mother (for example if she needs resuscitation). Latest data suggest that if possible delayed cord clamping/cutting should also be practiced for at least 1 minute if the baby does not breathe at birth. This means that the baby should remain between the mother's legs on the birthing bed and receive bag-mask lung inflations there. The baby should be dried and covered with a clean towel as usual and will receive warmth from being close to the mother's legs. See algorithm at the end of this chapter. 'Milking' of the cord is currently not recommended by MCAI.

Evidence suggests that air is safer for initial resuscitation than additional inspired oxygen. However, where possible additional oxygen should be available for use in case there is not a rapid improvement in the infant's condition. Equally, hyperoxia should be avoided, especially in the preterm infant. If a pulse oximeter is available, supplementary oxygen is not needed if SpO_2 is >85% 5 minutes after birth. SpO_2 needs to be measured from the right sided wrist or hand. If oxygen is given immediately after delivery, try to keep the SpO_2 at this time between 88% and 98%. Later aim for keeping SpO_2 94% to 98% at term or at > 32 weeks' gestation and 92% to 94% at or below 32 weeks' gestation.

Respiratory changes at birth in the newborn infant
The fetal lungs are fluid-filled, and the fetal circulation obtains oxygen from the placenta. At birth, the baby has to breathe air into the lungs to get oxygen into the circulation. To do this, fluid is removed from fetal lungs during labour and delivery:

Lung fluid is removed during labour and at birth by the following mechanisms:

- at the onset of labour, lung fluid production stops
- as labour progresses, re-absorption of lung fluid occurs
- fluid is removed from the lungs during vaginal delivery
- the first breaths generate relatively high pressures to inflate the lungs, which has the effect of pushing this fluid into the circulation. These first breaths establish the infant's resting lung volume, making breathing easier for the infant after these first breaths.

- Caesarean section is associated with delayed clearance of fluid from the lungs, which reduces the initial resting lung volume.

Surfactant is produced in the fetal alveoli to prevent them collapsing and decreases the work of breathing for the newborn.

Most surfactant is produced from 32 weeks to term so premature infants may need more breathing support for example CPAP (Continuous Positive Airways Pressure). Surfactant production is reduced by hypothermia, hypoxia and acidosis.

Regarding resuscitation of the newborn Infant
Most infants breathe well and do not need active 'resuscitation' at birth. Simply drying the infant with a warm dry sheet/towel will in most cases stimulate a cry from the infant thus expanding the lungs. Attempts to clear the airway, to stimulate breathing, or to give facial oxygen are unnecessary. Therefore, **routine airway suctioning is not needed.**

The practice of routinely performing direct oropharyngeal and tracheal suctioning of non-vigorous infants after birthIn the presence of clear amniotic fluid, routine oro-nasal pharyngeal suction (ONPS) in infants born vaginally and by Caesarean section is associated with harmful bradycardia, apnoea, and delays in achieving normal oxygen saturations, with no benefit.

Intra-partum oronasal pharyngeal suction whilst the fetal head is on the perineum and post-natal endotracheal suctioning of vigorous infants born through meconium-stained amniotic fluid (MSAF) does not prevent Meconium Aspiration Syndrome (MAS). Although depressed infants born through meconium are at risk of developing MAS, there is no evidence that endotracheal suctioning of these infants reduces MAS.

The value of suction where there is meconium-stained amniotic fluid was previously based upon poor evidence. The presence of thick, viscous meconium in a non-breathing infant where bag and mask ventilation is not inflating the lungs may be the **only** indication for **considering** visualising the oropharynx and suctioning material, which might be obstructing the airway. Tracheal intubation should never be routine in the presence of meconium and should only be performed for suspected tracheal obstruction. The emphasis is always on initiating ventilation within the first minute of life in non-breathing or ineffectively breathing infants by bag and mask ventilation and this should never be delayed.

Around 5% of infants do not breathe spontaneously after delivery. However, breathing can be started in almost all these infants by opening the airway and correctly applying bag-and-mask ventilation. With lung inflation there is an immediate and easily detectable rise in heart rate. It may be difficult to identify the infant's pulse rate by palpation at any site, so the best way to determine the heart rate is to listen over the chest with **a stethoscope**. If a stethoscope is not available try to listen with a Pinard or Ultrasonic probe or even with your own ear on the baby's chest.

Far less commonly, infants are born cyanosed, shocked, limp and hypotonic. Around 1% do not respond to bag- and-mask ventilation and need further help with advanced resuscitation.

Recent recommendations to the Neonatal Life Support Guidelines from The International Liaison Committee on Resuscitation (ILCOR) and European Resuscitation Council (ERC) relevant to resource-limited countries have been included in the algorithm at the end of this chapter.

Additional and important issues

The temperature of newly born infants should be maintained between 36.5ºC and 37.5ºC. Temperatures less than 36.5ºC have a strong association with increased morbidity and mortality. Even the mild hypothermia that was once felt to be inevitable and therefore clinically acceptable carries a risk. Therefore, the temperature in the delivery room should be at least 26 degrees C and immediately after birth the infant should be dried ideally in a warm towel and placed in dry towels and ideally a warm hat. However, this drying and wrapping should take less than 10 to 20 seconds, because rapid lung inflation by bag and mask ventilations are the key. As described above delayed cord clamping by keeping the baby between the mother's legs can help keep the baby warm.

In very small preterm infants the use of clear food-grade plastic wrapping (cling film) of the baby's body is recommended to maintain body temperature. A heated mattress on the resuscitation platform can be helpful.

For infants needing resuscitation, rapid/immediate intervention by airway opening and lung ventilation based resuscitation (in low resource settings usually by bag and mask) is the main priority as emphasised above.

Ventilatory resuscitation is best started with air. However, where possible, additional oxygen when available should be added to the bag and mask if there is no rapid improvement in the infant's condition.

Early application after resuscitation of nasal continuous positive pressure (CPAP) should be used to provide breathing support to all breathing infants who show signs of respiratory distress. Early use of nasal CPAP of + 5cm H_2O should be specially considered to keep the small airways open and make it easier to breathe in those spontaneously breathing preterm infants who are at high risk of developing respiratory distress syndrome (RDS).

Adrenaline should be given by the IV route (usually through the umbilical vein).

If there are no signs of life after 20 minutes of continuous and adequate resuscitation efforts, the baby's prognosis is poor, and discontinuation of resuscitation is recommended.

Sequence of actions during resuscitation of the newborn
The order of actions is listed below with explanations. For a summary of newborn resuscitation see algorithm (Figure 1.8) at end of this chapter.

1 Call for help

2 Start the clock or note the time
This will help document timing of actions and duration of resuscitation.

3 Dry the infant including the head.
Infants are born small and wet. They get cold very easily, especially if they remain wet and in a draught. Whatever the problem, **dry the infant well, including the head.** Remove the wet towel and wrap the infant in a dry towel. It is helpful if the towels are warm. The room in which delivery takes place should be clean, warm and free of drafts. A clean, warm and well-lit area is needed for resuscitation. Initially to support delayed cord clamping for at least 1 minute, lung inflations should be given to the baby lying between the mother's legs. After cord clamping the baby can be moved to an appropriate resuscitation platform. Although a source of radiant heat is helpful in keeping the infant warm, in low resource settings the provision of heat requires significant electrical power. The neonatal platform resuscitaire shown in Figure 1.1 is inexpensive compared with those used in well-resourced settings, does not have an overhead heater but is mobile, is safe from accidental falls of the infant, has a good low battery powered LED light, a large clock-face and place for resuscitation together with places to keep the bag and masks, suction systems and towels. Because of its low cost and minimal power requirements it is suitable for all facilities in which babies are born rather than being limited to hospitals.

There is good evidence that for very preterm infants (30 weeks' gestation or earlier), immediately covering the body, apart from the face, with clean plastic wrapping, by reducing evaporative heat loss is an effective way of keeping these very small infants warm during resuscitation. A woollen cap is available can also reduce heat loss.

Drying the infant immediately after delivery will provide significant stimulation during which skin and mucous membrane colour, tone, breathing and heart rate can continue to be assessed. Observing the breathing, skin colour, heart rate and tone helps to document the infant's condition and assess their response to resuscitation.

Figure 1.1 *Low cost mobile resuscitation platform for neonatal resuscitation*

However, stimulation is rarely sufficient for a baby who is not breathing, and no time should be wasted: if a baby is not breathing, lung inflation assistance within 20 seconds is essential.

Remember, that as soon as the baby is breathing or crying on their own, place immediately in skin-to-skin contact with the mother (providing she is well enough). If the mother is too ill, a relative or staff member can provide temporary skin to skin care and keep the baby warm.

4. **Assess breathing effort and count the heart rate**

If poor or no breathing effort, or only gasping, the baby will need urgent lung inflations.

The heart rate should be counted over ONLY a few seconds with a stethoscope on the chest. A heart rate less than 100/min in a newborn infant is almost always due to hypoxia and effective airway opening and bag-and-mask ventilation will cause an increase in heart rate. The heart rate is used to assess effectiveness of resuscitation because chest movement in a newborn infant may be difficult to see initially.

Reassess these observations regularly (particularly the heart rate), every 30 seconds or so, throughout the resuscitation process. The first sign of any improvement in the infant with a slow heart rate will be an increase in heart rate.

A healthy infant may be born blue but will have good tone, will cry within a few seconds of delivery, will have a good heart rate (the heart rate of a healthy new-born infant is approximately 120–150 beats/minute) and will rapidly become pink during the first 90 seconds or so. An ill infant will be born pale and floppy, not breathing, and with a slow (<100) or very slow (<60) heart rate.

The heart rate of an infant is best judged by listening to the chest with a stethoscope. It can also sometimes be felt by palpating the base of the umbilical cord, but a slow rate at the cord is not always indicative of a truly slow heart rate, and, if the infant is not breathing, must not delay the immediate application of lung inflations. In addition, **if the infant is not breathing, feeling for peripheral pulses is potentially harmful as it delays the onset**

of life-saving lung inflations. If a stethoscope is not available, you can listen to the heart by placing your ear on the infant's chest or using a Pinard or ultrasound stethoscope.

5. Airway: open the airway and keep it open

Before the infant can breathe effectively the airway must be open and must be kept open. This is one of the most important skills to learn to enable the newborn to get air into the lungs when he/she takes his/her first breath.
The upper airway of any infant who is born limp and hypotonic certainly needs to be opened and maintained in just the same way as the airway of any other unconscious patient. In an unconscious patient, pharyngeal tone decreases even more than it does during sleep, causing the upper airway to narrow or close. When such a patient is laid on their back the tongue also falls back, further obstructing the airway.
There are three ways to counteract this and open the airway

a. Hold the head in the neutral position *and*
b. Support the chin *or*
c. Push the lower jaw forward.

The best way to achieve this in an infant who is not breathing well is to place the infant on their back with the head in the neutral position (i.e. with the neck neither flexed nor extended and the face parallel with the surface the baby is lying on – Figure 1.2). Most newborn infants will have a relatively prominent occiput, which will tend to flex the neck if the infant is placed on their back on a flat surface. This can be avoided by placing some support using a folded nappy or cloth under the shoulders of the infant (1 to 2 cm thick) but be careful not to overextend the neck.

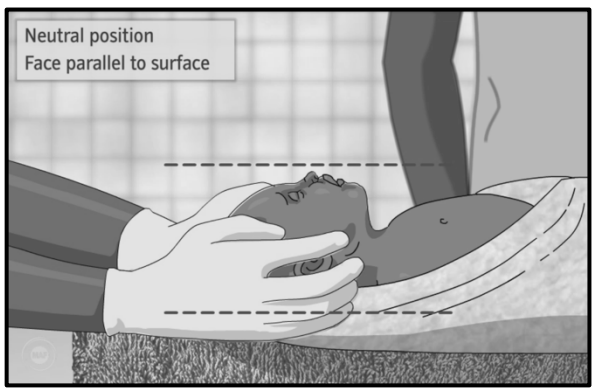


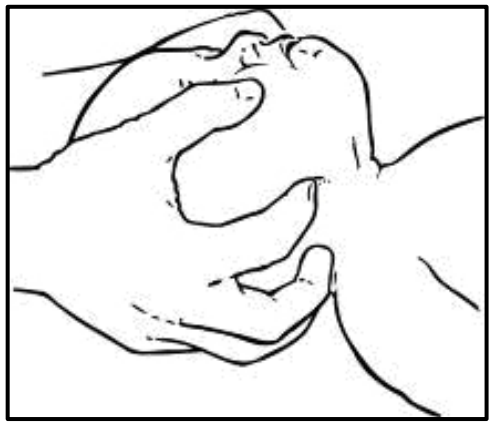
Figure 1.2 *Neutral position of the head and neck in a new-born infant*

If the infant is floppy it may also be necessary to apply chin lift or jaw thrust (see figures 1.3 and 1.4). It is important to support the bony part of the chin or jaw. *Pressure anywhere else may merely push the base of the tongue backwards, making matters worse.*

Figure 1.3 *Chin lift in a new-born infant. If tone is poor it may also be necessary to support the chin.*

If tone is very poor it may be necessary to use one or two fingers under each side of the lower jaw, at its angle to push the jaw forwards and outwards ('jaw thrust') (see Figure 1.4). A second person will then usually be needed to give the inflation and ventilation breaths by squeezing the bag (for which minimal training and skill is required).

Figure 1.4 *Jaw thrust in a new-born infant. Note that the operator's thumbs are in a position to hold a mask in place.*



The best way to stabilise an infant's condition at birth is to ensure that the upper airway **remains** unobstructed. The infant will then have little difficulty in drawing air into the lungs when it takes its first spontaneous gasp or cry.

Unfortunately, books often talk of the need to keep the airway 'clear', giving the false impression that the infant is going to find it difficult to breathe unless all the fluid and mucus is first sucked out of the way. There is no evidence that this is ever necessary unless the infant has thick meconium within the nasal or oral airway. Moreover, it can be harmful as blind deep suction of the nose or mouth can stimulate the vagus nerve, leading to bradycardia, apnoea and laryngospasm.

Routine **intrapartum (when the fetal face is on the perineum)** oropharyngeal and nasopharyngeal suctioning for infants born with clear and/or meconium-stained amniotic fluid is **not** recommended.

Tracheal obstruction
Although it is rare for debris to completely block the trachea, this should be suspected if an infant tries to breathe but remains cyanosed and bradycardic, with laboured breathing and marked inter-costal and/or sternal recession. This is one of the few situations where tracheal intubation can be lifesaving.

What to do if the trachea appears to be blocked by thick meconium
If the infant is born through meconium and cannot be ventilated by bag and mask at birth, the oropharynx should be inspected and cleared of meconium. If intubation skills are available, the larynx and trachea should also be cleared under direct vision.

If meconium has entered the trachea, resuscitation here is only possible if the accumulated debris can be immediately removed. The easiest way to do this is to pass an endotracheal tube and then remove the debris by direct suction to the endotracheal tube. Sometimes the

meconium debris is so large that it cannot be sucked through the tube. The tube can then be removed and replaced with a clean tube to clear the remaining obstructive material. Suction may also make it easier to see the larynx during intubation.

Breathing: Bag and mask inflation of the lungs
Having positioned the infant's airway correctly it is usually quite easy to use a self-inflating bag and mask to provide lung inflations.

If the infant is not breathing adequately give **five inflation breaths** as soon as possible. Until now the infant's lungs will have been filled with fluid. Aeration of the lungs in these circumstances is best with slow inflations at pressures of about 30 cmH_2O with the bag and mask; these are called 'inflation breaths. These initial ventilation breaths should last 2–3 seconds each. The aim is to mimic the initial breaths taken by a normal infant to open the airways, remove lung fluid and achieve its functional residual capacity. The chest may not move during the first one or two breaths as fluid is displaced.

If the baby is very preterm, such inflation breaths may injure immature lungs: give lower pressure ventilation breaths (see below) in this situation.

After 5 inflation breaths, check the heart rate. If the heart rate was below 100 beats/minute initially then it should rapidly increase as oxygenated blood reaches the heart. If the heart rate does increase, then you can assume that you have successfully aerated the lungs and there is adequate tissue oxygenation.

If the heart rate does not increase and/or is not greater than 100 beats per minute following 5 inflation breaths, the lungs have most likely not been aerated.
Consider adjusting the airway and /or mask

- Are the infant's head and neck in the neutral position?
- Do you need jaw thrust?
- Is the mask in the correct position on the face? that is covering the nose and mouth with no gap between the face and mask where air can escape
- Do you need a second person's help with the airway or to squeeze the bag? A relative or ward orderly can be asked to squeeze the self-inflating bag while you ensure that the mask is held firmly, in the best position on the face and with jaw thrust
- Is there an obstruction in the oropharynx (Inspect under direct vision)?

Check the airway is open and repeat 5 **inflation breaths** making sure that the chest expands with each breath.

If the heart rate increases but the infant does not start breathing, then continue to provide regular ventilation breaths at a rate of about 30–40 breaths/minute until the infant starts to breathe. Ventilation breaths resemble newborn infant's normal breathing and when undertaken through the bag and mask ensure sufficient pressures; that is just enough to see the chest move with each breath. Check every 30 to 60 seconds that the heart rate remains normal (above 100 beats/minute) and that there is no central cyanosis (best judged by looking at the colour of the tongue).

Continue ventilatory support until regular breathing is established.

Remember that the infant cannot breathe through the bag-valve-mask system, so do not leave the mask sealed to the face and expect the infant to breathe from the bag. The valve

between the bag and the mask prevents this. When the infant is breathing, remove the mask and watch closely to ensure that adequate breathing continues. If the tongue is not pink and oxygen is available, give additional inspired oxygen at 2 Litres/min.

Most infants will respond to bag-and-mask ventilation by gasping and then starting to breathe on their own without further support. If this does not happen, it is still easy to confirm that lung aeration has been achieved, because the heart rate will rise reliably and consistently above 100 beats/minute. If lung aeration has been achieved and the infant still has a slow heart rate, proceed to support the circulation (C).

If oxygen is available, applying this through the bag and mask may also help.

Correct bag-and-mask ventilation is the single most important skill needed to provide effective resuscitation.

There is good evidence that most infants can be resuscitated using mask resuscitation without any need for tracheal intubation. However, a small proportion of such infants require early intubation, so the equipment and the skill to intubate should ideally be available.

Figure 1.5 Mouth-to-mouth and nose resuscitation

Most current guidelines on neonatal care avoid discussing the role of mouth-to-mouth and nose resuscitation. The risk of HIV infection or hepatitis has further supported that reluctance. However, there is no doubt that this can be an effective way of reviving an apparently lifeless infant in the absence of equipment. Remember the following:

- Keep the upper airway open by optimising the position of the head and jaw as described above.
- Cover the infant's nose and mouth with your mouth (or cover the mouth of a big infant and just pinch the nose).
- Use the pressure you can generate with your cheeks and try to aerate the lung by slow inflations for 2–3 seconds.
- Only use as much air for each breath as you can keep in your cheeks (i.e. do not 'blow' air into the infant, but just small puffs).
- Watch for chest movement and allow time for lung recoil.
- Once the chest starts to move, sustain what has been achieved with 20–25 artificial breaths/minute.

Checking progress with resuscitation before moving on

- If the heart rate has not risen to over 100 beats/minute after the five initial breaths or within 30 seconds of adequate ventilation, something is wrong. The most likely problem is that you have not successfully ventilated the infant. Never move on to deal with the issues covered under letter C of the resuscitation alphabet until you are quite sure you have achieved objectives A and B. To do so is quite futile. Chest compressions will never restore the circulation until the blood being massaged from the lung to the heart contains oxygen.
- Look to see whether the chest moves each time you apply mask pressure. Movement should not be difficult to see once the first few breaths have aerated the lungs. It is usually easier to judge success with your eyes than with a stethoscope. In a newborn,

breath sounds can be heard when only the airway is being aerated, so are not a good way to judge ventilatory success.

- Check that the infant's head is well positioned. Check chin support and jaw thrust, and that the mask is correctly applied with no air leaks. Ask a second person to help you position the infant optimally and provide inflations by squeezing the bag while you hold the airway open, the mask in place and apply jaw thrust.
- Few infants need support with their breathing once their lungs have been aerated. Most will gasp, cry or breathe just as soon as an attempt is made to get air into the lungs, and then continue breathing adequately.
  - However, a few may benefit from further support if they do not start to breathe regularly, or only gasp occasionally. Some may have suffered severe hypoxia in utero, and a few may be drowsy because of drugs given to the mother during labour. Check that the heart rate remains normal (above 100 beats/minute) and that there is no central cyanosis (best judged by looking at the colour of the tongue).
  - Try to assess whether there is hypoxemia (cyanosis or SpO_2 less than 90% with a pulse oximeter), if the infant's breathing remains laboured and irregular or if the infant's colour remains blue. Give oxygen then if it is available, preferably with SpO_2 monitoring. Hyaline membrane disease, meconium aspiration syndrome, pneumonia or transient tachypnoea of the newborn are most likely.
    Other possibilities for failed breathing include:
    - intra-partum pneumonia (common)
    - diaphragmatic hernia
    - pneumothorax
    - pulmonary hypoplasia (possibly associated with a skeletal or renal abnormality)
    - cyanotic congenital heart disease (although this usually takes a little time to appear)
    - persistent fetal circulation.
  - If breathing requires continuous support, it is important to try and reduce mask inflation pressures to little more than half of what was needed to aerate the lung in the first place. It is easy to over-ventilate an infant with healthy lungs and to wash out so much of the carbon dioxide that normally provides the main stimulus to breathing that all such activity stops for a while. There is evidence that sustained over-ventilation can reduce cerebral blood flow.

Endotracheal intubation
As discussed earlier, most infants who need resuscitation can be managed with bag-valve-mask intubation. However, occasionally endotracheal intubation is required, but this must be done by someone skilled and practised in the technique. It is most likely to be required for prolonged resuscitation, in meconium aspiration, and in preterm infants with surfactant deficiency. A straight-bladed laryngoscope is preferred, and tube sizes are around 3.5 mm for a term infant and 2.5 mm for a preterm infant. Sizes larger and smaller than these should be available.

Resuscitation of preterm infants
Infants with surfactant deficiency may have difficulty in expanding their lungs, and in developing a normal functional residual capacity at birth.
However, the preterm lung is quite a delicate structure with relatively little elastic support, and any use of undue pressure or excessive ventilation during resuscitation can damage the lungs.

While an inspiratory pressure of 30 cm H_2O may well be necessary to begin aerating the lungs at birth, the pressure should be reduced as rapidly as possible to a level that ensures that the chest is moving adequately. The key aim must be to conserve such surfactant as already exists by sustaining the lung's functional residual capacity (an objective best

achieved by providing at least 5 cm H_2O of Positive End-Expiratory Pressure (PEEP). Aim to achieve this consistently throughout transfer to the neonatal unit. This can be achieved using nasal prongs (nasal CPAP), thus avoiding tracheal intubation altogether (see Handbooks 1 and 2 on paediatric illnesses).

Orogastric aspiration of air
If resuscitation is successful, there may be enough air inside and expanding the stomach to make it difficult for the baby to breathe due to pressure on the diaphragm. Passing an orogastric tube and aspirating air or placing it on open drainage may make it easier for the baby to breathe.

Circulation: chest compressions
Most infants needing help at birth will respond to successful lung inflation with an increase in heart rate followed quickly by normal breathing. Chest compressions should be started only when you are sure that the lungs are being aerated successfully.

If the heart rate remains very slow (less than 60 beats/minute) or absent following 60 seconds of ventilation with good chest movements, start chest compressions.

In infants, the most efficient method of delivering chest compressions is to grip the chest in both hands in such a way that the two thumbs can press on the lower third of the sternum, just below an imaginary line joining the nipples, with the fingers over the spine at the back. This can only be done if there is a second operator ventilating the lungs (see Figure 1.6)

If you are alone, the two-thumb method is not possible, as ventilations also need to be provided. In this situation, use the first two fingers of one hand to depress the lower sternum, while the other hand holds the mask in place (Figure 1.7). Then move the hand from the sternum to squeeze the bag or ask a relative or other member of staff to do this: it does not require training.

Compress the chest quickly and firmly, reducing the antero-posterior diameter of the chest by about one-third.

Because oxygenation is such an important part of neonatal resuscitation, the recommended ratio of compressions to inflations in newborn resuscitation is 3:1.

Chest compressions move oxygenated blood from the lungs back to the heart and out into the ascending aorta. From there the two coronary arteries will then quickly deliver oxygen to the failing heart muscle.

Chest compressions also can induce some air to enter the lungs.

It is important to allow enough time during the relaxation phase of each compression cycle for the heart to refill with blood, at the same time ensuring that the chest is inflating with each breath.

Figure 1.6 *Two-thumb compression of the chest, with a second operator ventilating the lungs, here using a T-piece as an alternative to bag and mask.*

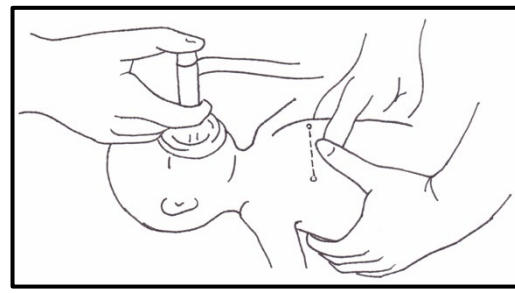
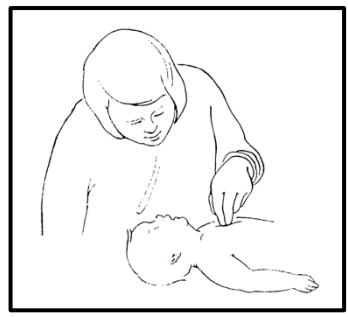


Figure 1.7 Two-finger chest compressions. The other hand can hold the mask on the face



The rate of chest compressions is around 120/minute. However, with pauses for ventilation, the actual total number of compressions is less than 120/minute.

Check heart rate every 30 seconds – when heart rate reaches more than 60/min stop cardiac compressions

Continue ventilation breaths until baby is breathing.

If there no cardiac output despite effective lung ventilation and chest compressions, then the outlook for the infant is poor.

Drugs
Rarely inflation of the lungs and effective chest compression will not be sufficient to produce adequate circulation and perfusion in infants. In these circumstances, drugs may be helpful. However, drugs are needed only if there is no significant cardiac output despite effective lung inflation and chest compression.

Very few drugs have proved to be of benefit. The most used drug is Adrenaline (1:10 000). This is best delivered via an umbilical venous catheter when peripheral IV access is not possible. The intra-osseous route may also be used. Each injection of a drug should be followed with a bolus of 2–3 mL of Ringer- Lactate/ Hartmann's or 0.9% saline.

Unfortunately, most of the infants in whom cardiac output only returns after drug treatment require specialist neonatal care (often with mechanical ventilation) and do not survive to discharge. Most of those who do survive later develop profound disabling spastic quadriplegia.

Where the cause of the infant's terminal apnoea is a sudden and much more abrupt hypoxic event (such as shoulder dystocia or an occasional case of late cord prolapse) these

reservations may be less valid. Here there is at least anecdotal evidence that the outlook is much less bleak if the circulation can be restarted.

Acidosis not serious enough to precipitate circulatory standstill (asystole) will nearly always correct itself spontaneously within 90 minutes once the circulation has been restored and the infant starts to breathe for him- or herself. It does not therefore call for sodium bicarbonate, the use of which is controversial. Indeed, giving bicarbonate may increase carbon dioxide levels, worsening intracellular acidosis, and increases the amount of sodium that the potentially compromised kidney will need to excrete over the next few days.

Adrenaline: The recommended dose of adrenaline is 10 micrograms/kg body weight (0.1 mL/kg body weight of 1:10,000 solution). If this is not effective, a dose of up to 30 micrograms/kg (0.3 mL/kg body weight of 1:10 000 solution) may be tried. Ideally, have ready-made and well-labelled 1:10 000 adrenaline solutions available on all emergency trolleys. In situations where this is not available in a ready-made state it could be prepared by adding 1 mL of 1:1000 solution to 9 mL of 0.9% saline or Ringer-Lactate/ Hartmann's solution. It is potentially dangerous to leave inadequately labeled and made up doses of adrenaline around, as giving the same volume of 1:10,000 as a 1:1000 solution could cause cardiac arrest.
Never give any drug into the umbilical artery.

Naloxone (nalorphine) can be used to reverse profound opiate-induced respiratory depression in the newborn following high doses of morphine in the mother during pregnancy or delivery. If it does prove necessary, it is best to give it intramuscularly and give a full 200-microgram 'depot' dose irrespective of body weight. If naloxone is given as a single dose IV, it will be eliminated from the body faster than the opioid drug, causing a return of the respiratory depression, and therefore the infant may stop breathing again without a naloxone infusion. Naloxone does not reverse the respiratory depressing effects of non-opiate drugs.

Acute blood loss as a cause of circulatory arrest (circulatory volume support)
Sudden acute blood loss is a rare, but often unrecognised, cause of acute circulatory collapse. Bleeding from an aberrant placental blood vessel (vasa praevia) or snapped umbilical cord can rapidly lead to hypovolaemic death. Other less well-recognised causes of hypovolaemic collapse include acute feto–maternal blood loss, sudden twin-to-twin transfusion, accidental incision of the placenta during Caesarean delivery and a cord ligature that has come off and not been detected.

The response to a rapid infusion of 10ml/Kg of 0.9% saline or Ringer Lactate /Hartmann's solution can be lifesaving.

Circulatory collapse probably does not occur until the infant has lost 30–40 mL/kg of blood, but 10 mL/kg of Ringer-lactate/Hartmann's solution or 0.9% saline will usually reverse the immediate critical hypovolaemia rapidly. The initial intravenous fluid bolus would ideally be 10ml/Kg of blood group O Rh-negative blood). This can be repeated once if there is no or only minimal response. A packed red cell transfusion using group-specific, or group O Rh-negative duly cross-matched blood can be given later to correct the associated anaemia.

Apart from the above specific indications, IV fluid boluses should not be used during neonatal resuscitation. There is no evidence to suggest benefit from routine use, which only compounds the problem of fluid balance that can develop over the next 2 to 3 days if severe intra-partum hypoxic ischaemic injury causes renal failure.

Poor response to resuscitation

If the infant either fails to respond or shows a poor response to resuscitation, the most likely problem is inadequate oxygenation. The following steps should be considered:

1. Check the airway and ventilation.
2. Check for technical faults if using advanced equipment.
    a. Is the oxygen attached?
    b. Is the airway blocked?
    c. Is the endotracheal tube in the correct place?
3. Re-examine the chest to see if a pneumothorax has developed. This is not common but may cause a problem. Drain a tension pneumothorax with a small cannula over needle (21 gauge) in the second intercostal space in the mid-clavicular line. This should be followed by the insertion of a chest drain (see Section 38).
4. Consider the possibility of a congenital heart lesion (see Section 26) if the infant remains cyanosed despite breathing and having a good heart rate.
5. Consider the possibility that excessive assisted ventilatory breaths may have driven blood carbon dioxide to a low level thereby removing one of the drives by the brain to breathe spontaneously.
6. Consider the possibility of maternal opiates or sedation, such as diazepam or phenobarbitone, if the infant is pink, well perfused, but requires assisted ventilation.
7. Shock, caused by acute blood loss, should respond to a rapid bolus of 10–20 mL/kg of O-negative blood (see above).
8. Always consider the possibility of hypoglycaemia

Stopping resuscitation

Even with the most effective resuscitation, not all infants will survive. If the infant has been without a cardiac output after 20 minutes of resuscitation and does not respond despite effective ventilations and chest compressions, the outcome is unlikely to be altered by the use of drugs, although these should be considered. The decision to stop resuscitation should be taken by the most senior healthcare worker present, and the reason for the decision should be clearly documented. Explain sensitively to the parents that the infant has died. The infant should then be handled in accordance with cultural preference and practice.

Apgar scores

Anaesthetist Virginia Apgar introduced these in 1953. Each factor in the Table 1.1 below is given a score between zero and two, which are then added up to give the total score. The baby's skin colour is looked at to see if their blood is circulating properly. It can be harder to detect bluish skin or a lack of colour in black and Asian babies so check the tongue and mouth.

How does MCAI suggest you use the Apgar scores

For those babies who do not need resuscitation, the baby's wellbeing from two Apgar scores can be calculated in real time one minute after birth, and again at five minutes after birth. Each factor in Table 1.1 is given a score between zero and two, which are then added up to give the total Apgar score for each of the 2 measurements.

Score	0	1	2	Acronym
Skin	Entire body blue or lacks colour especially mouth and tongue	Good colour but bluish hands or feet	Good colour all over	**A**ppearance
Heart rate	Absent	Slow <100	Fast > 100	**P**ulse
Reflex responses	No response to stimulation when drying	Grimacing facial movements when stimulated	Crying and/or coughing	**G**rimace
Muscle tone	Limp when drying	Some bending or stretching of limbs	Active movements	**A**ctivity
Breathing	Absent or gasping	Weak or irregular	Good and crying	**R**espiration

Table 1.1

Apgar scores when a baby needs resuscitation

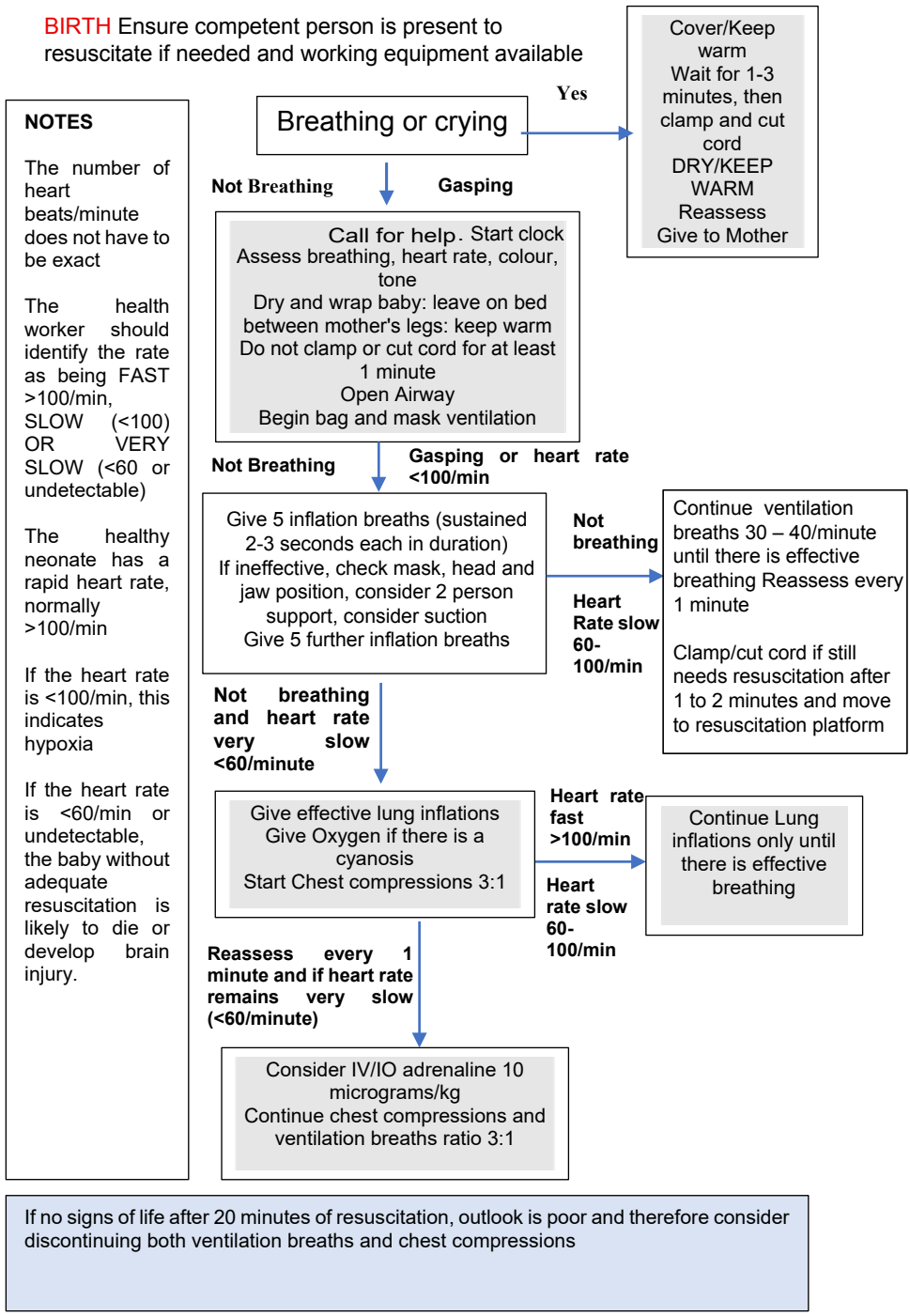
If the baby needs resuscitation, calculating the Apgar scores during resuscitation can interfere with vital aspects of treatment (ABC) and these scores can be recalled and documented when the baby no longer needs resuscitation. However, the 5 minute score is only helpful if the baby has recovered and is no longer being resuscitated. If the baby continues to need resuscitation for > 5 minutes after birth, then we suggest that the second Apgar score is undertaken only when resuscitation has ended successfully. At this time this score is documented along with the total duration of the resuscitation given in minutes (for example 9 after 12 minutes).

However, if resuscitation is discontinued and/or the baby dies, then a timed second Apgar score can be documented (for example zero at 20 minutes).

Low Apgar scores (scores < 7) after resuscitation has ended and the baby is alive means that further inpatient neonatal specialist care is required.

The Apgar score is only one measure of newborn well-being and, especially if the second Apgar score after the end of resuscitation is < 7, or there are other concerns related to Hypoxic Ischaemic Injury such as poor feeding and seizures, there should be further checks over the coming days, weeks and months to assess the baby's development and implement measures to improve development if this is delayed.

Resuscitation of the newborn Infant MCAI version: see UK and European Resuscitation Councils' versions, especially if preterm <32 weeks



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