11 Newborn Life Support

Introduction

Passage through the birth canal is a hypoxic experience for the fetus, since significant respiratory exchange at the placenta is prevented for the 50-75 s duration of the average contraction. Though most babies tolerate this well, the few that do not may require help to establish normal breathing at delivery. Newborn life support (NLS) is intended to provide this help and comprises the following elements:

- drying and covering the newborn baby to conserve heat;
- assessing the need for any intervention;
- opening the airway;
- aerating the lung;
- rescue breathing;
- chest compression;
- administration of drugs (rarely).

Physiology

If subjected to sufficient hypoxia in utero, the fetus will attempt to breathe. If the hypoxic insult is continued the fetus will eventually lose consciousness. Shortly after this the neural centres controlling these breathing efforts will cease to function because of lack of oxygen. The fetus then enters a period known as primary apnoea.

Up to this point, the heart rate remains unchanged, but soon decreases to about half the normal rate as the myocardium reverts to anaerobic metabolism – a less fuel-efficient mechanism. The circulation to non-vital organs is reduced in an attempt to preserve perfusion of vital organs. The release of lactic acid, a by-product of anaerobic metabolism, causes deterioration of the biochemical milieu.

If the insult continues, shuddering (whole-body gasps at a rate of about 12 min^{-1}) are initiated by primitive spinal centres. If the fetus is still in utero, or if for some other reason these gasps fail to aerate the lungs, they fade away and the fetus enters a period known as secondary, or terminal, apnoea. Until now, the circulation has been maintained but, as terminal apnoea progresses, the rapidly deteriorating biochemical milieu begins to impair cardiac function. The heart eventually fails and, without effective intervention, the baby dies. The whole process probably takes almost 20 min in the term newborn human baby.

Thus, in the face of asphyxia, the baby can maintain an effective circulation throughout the period of primary apnoea, through the gasping phase, and even for a while after the onset of terminal apnoea. Thus, the most urgent requirement for any asphyxiated baby at birth is that the lungs be aerated effectively. Provided the baby's circulation is sufficient, oxygenated blood will then be conveyed from the aerated lungs to the heart. The heart rate will increase and the brain will be perfused with oxygenated blood. Following this, the neural centres responsible for normal breathing will, in many instances, function once again and the baby will recover.

Merely aerating the lungs is sufficient in the vast majority of cases. Although lung aeration is still vital, in a few cases cardiac function will have deteriorated to such an extent that the circulation is inadequate and cannot convey oxygenated blood from the aerated lungs to the heart. In this case, a brief period of chest compression may be needed. In a very few cases, lung aeration and chest compression will not be sufficient, and drugs may be required to restore the circulation. The outlook in this group of infants is poor.

Important guideline changes

The following are the main changes that have been made to the NLS guidelines in 2010:[270, 287]

- For uncompromised babies, a delay in cord clamping of at least one minute from the complete delivery of the infant, is now recommended. As yet there is insufficient evidence to recommend an appropriate time for clamping the cord in babies who are severely compromised at birth. For babies requiring resuscitation, resuscitative intervention remains the priority.
- For term infants, air should be used for resuscitation at birth. If, despite effective ventilation, oxygenation (ideally guided by pulse oximetry) remains unacceptable, use of a higher concentration of oxygen should be considered.
- Preterm babies less than 32 weeks gestation may not reach the same arterial blood oxygen saturations in air as those achieved by term babies. Therefore blended oxygen and air should be given judiciously and its use guided by pulse oximetry. If a blend of oxygen and air is not available use what is available.
- Preterm babies of less than 28 weeks gestation should be completely covered up to their necks in a food-grade plastic wrap or bag, without drying, immediately after birth. They should then be nursed under a radiant heater and stabilised. They should remain wrapped until their temperature has been checked after admission. For these infants delivery room temperatures should be at least 26°C.
- The recommended compression:ventilation ratio for CPR remains at 3:1 for newborn resuscitation.
- Attempts to aspirate meconium from the nose and mouth of the unborn baby, while the head is still on the perineum, are not recommended. If

presented with a floppy, apnoeic baby born through meconium it is reasonable to inspect the oropharynx rapidly to remove potential obstructions. If appropriate expertise is available, tracheal intubation and suction may be useful. However, if attempted intubation is prolonged or unsuccessful, start mask ventilation, particularly if there is persistent bradycardia.

- If adrenaline is given then the intravenous route is recommended using a dose of 10-30 mcg kg^{-1}. If the tracheal route is used, it is likely that a dose of at least 50-100 mcg kg^{-1} will be needed to achieve a similar effect to 10 mcg kg^{-1} intravenously.
- Detection of exhaled carbon dioxide (capnography) in addition to clinical assessment is recommended as the most reliable method to confirm placement of a tracheal tube in neonates with a spontaneous circulation.
- Newly born infants born at term or near term with evolving moderate to severe hypoxic – ischaemic encephalopathy should, where possible, be treated with therapeutic hypothermia.

Suggested sequence of actions

Keep the baby warm and assess

Babies are born small and wet. They get cold very easily, especially if they remain wet and in a draught. For uncompromised babies, a delay in cord clamping of at least one minute from the complete delivery of the infant, is recommended.

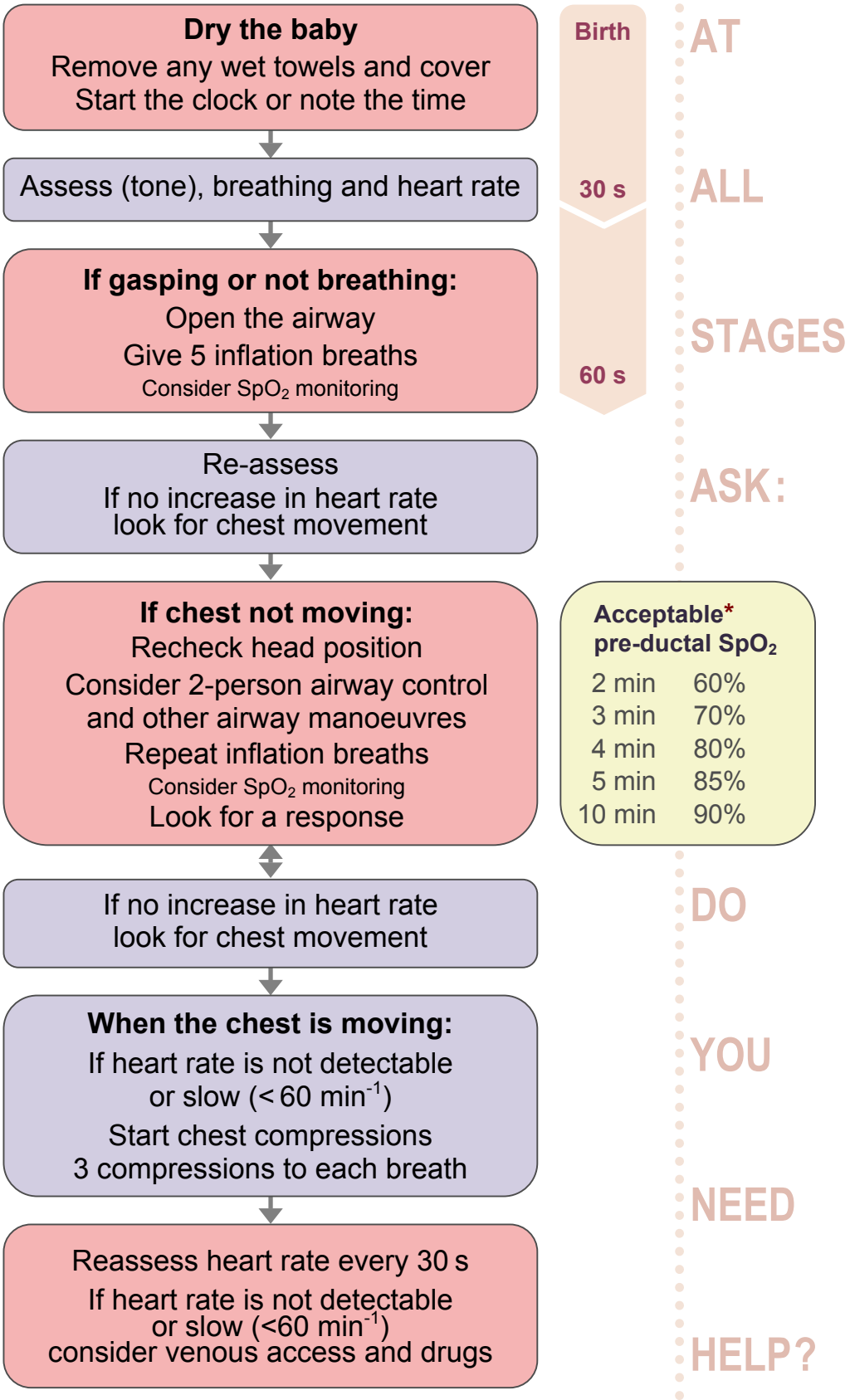
Whatever the situation it is important that the baby does not get cold at this stage. If intervention is required, in a term or near-term baby, dry the baby, remove the wet towels, and cover the baby with dry towels.

Significantly preterm babies are best placed, without drying, into food-grade plastic wrapping under a radiant heater. This process will provide significant stimulation and will allow time to assess tone, breathing, and heart rate.

Reassess these observations regularly every 30 s or so throughout the resuscitation process but it is the heart rate which is the key observation. The first sign of any improvement in the baby will be an increase in heart rate. Consider the need for help; if needed, ask for help immediately.

A healthy baby will be born blue but will have good tone, will cry within a few seconds of delivery and will have a good heart rate within a few minutes of birth (the heart rate of a healthy newborn baby is about 120-150 min^{-1}). A less healthy baby will be blue at birth, will have less good tone, may have a slow heart rate (less than 100 min^{-1}), and may not establish adequate breathing by 90-120 s. An ill baby will be born pale and floppy, not breathing and with a slow, very slow or undetectable heart rate.

Newborn Life Support



* See reference 297

Keep the baby warm and assess (continued)

The heart rate of a baby is judged best by listening with a stethoscope. It can also be felt by gently palpating the umbilical cord but a slow rate at the cord is not always indicative of a truly slow heart rate – feeling for peripheral pulses is not helpful.

A pulse oximeter is probably the best way of assessing heart rate and oxygenation in the delivery room. With practice it is possible to attach a pulse oximeter probe and to obtain a useful reading of heart rate and oxygen saturation about 90 s after delivery.[288]

Airway

Before the baby can breathe effectively the airway must be open. The best way to achieve this is to place the baby on his back with the head in the neutral position, i.e. with the neck neither flexed nor extended. Most newborn babies will have a relatively prominent occiput, which will tend to flex the neck if the baby is placed on his back on a flat surface. This can be avoided by placing some support under the shoulders of the baby, but be careful not to overextend the neck. If the baby is very floppy (i.e. has no or very little tone) it may also be necessary to apply chin lift or jaw thrust. These manoeuvres will be effective for the majority of babies requiring airway stabilisation at birth.

Airway suction immediately following birth should be reserved for babies who have obvious airway obstruction that cannot be rectified by appropriate positioning. Rarely, material may be blocking the oropharynx or trachea. In these situations, direct visualisation and suction of the oropharynx should be performed. For tracheal obstruction, intubation and suction on withdrawal of the endotracheal tube may be effective.

Breathing

Most babies have a good heart rate after birth and establish breathing by about 90 s. If the baby is not breathing adequately **give 5 inflation breaths**, preferably using air. Until now the baby's lungs will have been filled with fluid. Aeration of the lungs in these circumstances is likely to require sustained application of pressures of about 30 cm H_2O for 2-3 s – these are 'inflation breaths' (20-25 cm H_2O in preterm babies). If the heart rate was below 100 min^{-1} 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.
- If the heart rate increases but the baby does not start breathing for himself, then continue to provide regular breaths at a rate of about 30-40 min^{-1} until the baby starts to breathe on his own.
- If the heart rate does not increase following inflation breaths, then either you have not aerated the lungs or the baby needs more than lung aeration alone. By far the most likely is that you have failed to aerate the lungs effectively.

- If the heart rate does not increase, *and* the chest does not passively move with each inflation breath, then you have not aerated the lungs.

If the lungs have not been aerated then consider:

- Is the baby's head in the neutral position?
- Do you need jaw thrust?
- Do you need a longer inflation time?
- Do you need a second person's help with the airway?
- Is there an obstruction in the oropharynx (laryngoscope and suction)?
- What about an oropharyngeal (Guedel) airway?
- Is there a tracheal obstruction?

Check that the baby's head and neck are in the neutral position; that your inflation breaths are at the correct pressure and applied for sufficient time (2-3 s inspiration); and that the chest moves with each breath. If the chest still does not move, ask for help in maintaining the airway and consider an obstruction in the oropharynx or trachea, which may be removable by suction under direct vision. An oropharyngeal (Guedel) airway may be helpful.

If the heart rate remains slow (less than 60 min^{-1}) or absent following 5 inflation breaths, despite good passive chest movement in response to your inflation efforts, start chest compression.

Chest compression

Almost all babies needing help at birth will respond to successful lung inflation with an increase in heart rate followed quickly by normal breathing. However, in some cases chest compression is necessary.

Chest compression should be started only when you are sure that the lungs have been aerated successfully.

In babies, the most efficient method of delivering chest compression 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.

Compress the chest quickly and firmly, reducing the antero-posterior diameter of the chest by about one third.[289]

The ratio of compressions to inflations in newborn resuscitation is 3:1.

Chest compressions move oxygenated blood from the lungs back to the heart. Allow enough time during the relaxation phase of each compression cycle for the heart to refill with blood. Ensure that the chest is inflating with each breath.

In a very few babies (less than one in every thousand births) inflation of the lungs and effective chest compression will not be sufficient to produce an effective circulation. In these circumstances drugs may be helpful.

Drugs

Drugs are needed rarely and only if there is no significant cardiac output despite effective lung inflation and chest compression.

The drugs used include adrenaline (1:10,000), occasionally sodium bicarbonate (ideally 4.2%), and dextrose (10%). They are best delivered via an umbilical venous catheter.

The recommended intravenous dose for adrenaline is 10 mcg kg^{-1} (0.1 ml kg^{-1} of 1:10,000 solution). If this is not effective, a dose of up to 30 mcg kg^{-1} (0.3 ml kg^{-1} of 1:10,000 solution) may be tried.

If the tracheal route is used, it must not interfere with ventilation or delay acquisition of intravenous access. The tracheal dose is thought to be between 50-100 mcg kg^{-1}.

The dose for sodium bicarbonate is between 1 and 2 mmol of bicarbonate kg^{-1} (2 to 4 ml of 4.2% bicarbonate solution).

The dose of dextrose recommended is 250 mg kg^{-1} (2.5 ml kg^{-1} of 10% dextrose).

Very rarely, the heart rate cannot increase because the baby has lost significant blood volume. If this is the case, there is often a clear history of blood loss from the baby, but not always. Use of isotonic crystalloid rather than albumin is preferred for emergency volume replacement. In the presence of hypovolaemia, a bolus of 10 ml kg^{-1} of 0.9% sodium chloride or similar given over 10 - 20 s will often produce a rapid response and can be repeated safely if needed.

Explanatory Notes

Resuscitation or stabilisation

Most babies born at term need no resuscitation and they can usually stabilise themselves during the transition from placental to pulmonary respiration very effectively. Provided attention is paid to preventing heat loss and a little patience is exhibited before cutting the umbilical cord, intervention is rarely necessary. However, as mentioned above, some babies will have suffered stresses or insults during labour. Help may then be required which is characterised by interventions designed to rescue a sick or very sick baby and this process can then reasonably be called resuscitation.

Significantly preterm babies, particularly those born below 30 weeks gestation, are a different matter. Most babies in this group are healthy at the time of delivery and yet all can be expected to benefit from help in making the transition. Intervention in this situation is usually limited to maintaining a baby healthy during this transition and is more appropriately called stabilisation.

In the past both situations have been referred to as resuscitation and this seems inappropriate and likely to cause confusion.

Umbilical cord clamping

For healthy term infants delaying cord clamping for at least one minute or until the cord stops pulsating following delivery improves iron status through early infancy.[290] For preterm babies in good condition at delivery, delaying cord clamping for up to 3 min results in increased blood pressure during stabilisation, a lower incidence of intraventricular haemorrhage and fewer blood transfusions.[291] However, babies were more likely to receive phototherapy. There are limited data on the hazards or benefits of delayed cord clamping in the non-vigorous infant.[292, 293]

Delaying cord clamping for at least one minute is recommended for newborn infants not requiring resuscitation.[287] At present there is insufficient evidence to define an appropriate time to clamp the cord in babies apparently needing resuscitation. However, this may be because time is the wrong defining parameter and perhaps the cord should not be clamped until the baby has started breathing.

Oximetry and the use of supplemental oxygen

If resources are available, pulse oximetry should be used for all deliveries where it is anticipated that the infant may have problems with transition or need resuscitation. Oxygen saturation and heart rate can be measured reliably during the first minutes of life with a modern pulse oximeter.[287]

The sensor must be placed on the right hand or wrist to obtain an accurate reading of the preductal saturation.[294, 295] Placement of the sensor on the baby before connecting to the instrument may result in faster acquisition of signal. In most cases a reliable reading can be obtained within 90 s of birth.[296] Pulse oximetry can also provide an accurate display of heart rate during periods of good perfusion.

In healthy term babies, oxygen saturation increases gradually from approximately 60% soon after birth to over 90% at 10 min. In preterm infants hyperoxaemia is particularly damaging and if oxygen is used to achieve a saturation above 95% the risk of hyperoxaemia is high. Therefore the rate of rise in oxygen saturation after birth in preterm infants should not exceed that seen in term infants, although some supplemental oxygen may be required to achieve this.[297, 298]

Colour

Using colour as a proxy for oxygen saturation is usually inaccurate.[299] However, noting whether a baby is initially very pale and therefore either acidotic or anaemic at delivery may be useful as an indicator for later therapeutic intervention.

Airway suctioning with or without meconium

A multi-centre randomised controlled trial has shown that routine elective intubation and suctioning of vigorous infants at birth, did not reduce meconium aspiration syndrome (MAS).[300] A further randomised study has shown that suctioning the nose and mouth of

such babies on the perineum and before delivery of the shoulders (intrapartum suctioning) is also ineffective.[301] Whilst non-vigorous infants born through meconium-stained amniotic fluid are at increased risk of MAS, tracheal suctioning has not been shown to improve the outcome.

There is no evidence to support or refute suctioning of the mouth and nose of babies born through clear amniotic fluid.

Recommendation

Routine *intrapartum* oropharyngeal and nasopharyngeal suctioning for infants born with clear and/or meconium-stained amniotic fluid is not recommended. In the absence of randomised, controlled trials, there is insufficient evidence to recommend a change in the current practice of performing direct oropharyngeal and tracheal suctioning of non-vigorous babies after birth with meconium-stained amniotic fluid if feasible. However, if attempted intubation is prolonged or unsuccessful, mask ventilation should be implemented, particularly if there is persistent bradycardia.

Laryngeal mask

Several studies have shown that laryngeal mask airways (LMAs) can be used effectively at birth to ventilate the lungs of babies weighing over 2000 g, greater than 33 weeks gestation and apparently needing resuscitation. Case reports suggest that LMAs have been used successfully when intubation has been tried and failed – and occasionally vice-versa. Data on smaller or less mature babies are scarce.

Recommendation

The LMA should be considered during resuscitation of the newborn if face mask ventilation is unsuccessful and tracheal intubation is unsuccessful or not feasible. The LMA may be considered as an alternative to a face mask for positive pressure ventilation among newborns weighing more than 2000 g or delivered ≥ 34 weeks gestation. There is limited evidence, however, to evaluate its use for newborns weighing < 2000 g or delivered < 34 weeks gestation. The LMA may be considered as an alternative to tracheal intubation as a secondary airway for resuscitation among newborns weighing more than 2000 g or delivered ≥ 34 weeks gestation. The LMA has not been evaluated in the setting of meconium stained fluid, during chest compressions, or for the administration of emergency intra-tracheal medications.

Exhaled carbon dioxide

Detection of exhaled carbon dioxide confirms tracheal intubation in neonates with a cardiac output more rapidly and more accurately than clinical assessment alone. False negative readings may occur in very low birth weight neonates and in infants during cardiac arrest. False positives may occur with colorimetric devices contaminated with adrenaline, surfactant and atropine.

Drugs in resuscitation at birth

Ventilation and chest compression may fail to resuscitate fewer than 1 in 1000 babies.[302] In this group, resuscitation drugs may be justified. Whilst there is evidence from animal studies for both adrenaline and sodium bicarbonate in increasing return of spontaneous circulation, there is no placebo-controlled evidence in human babies for the effectiveness of any drug intervention in this situation. Even for adults and children in cardiac arrest, there is insufficient evidence to suggest that vasopressors improve survival to discharge.

For this reason use of drugs before achieving lung aeration followed by chest compressions (known to be effective resuscitative interventions) can never be justified.[270]

Therapeutic hypothermia

Term or near-term infants, with evolving moderate to severe hypoxic-ischaemic encephalopathy, should be treated with therapeutic hypothermia.[303-306] Whole body cooling and selective head cooling are both appropriate strategies.[304-308] Cooling should be initiated and conducted under clearly-defined protocols with treatment in neonatal intensive care facilities and the capabilities for multidisciplinary care. Treatment should be consistent with the protocols used in the randomised clinical trials, i.e. commence within 6 h, continue for 72 h and re-warm over at least 4 h. All treated infants should be followed longitudinally and permission sought for their inclusion in the TOBY (Total Body Hypothermia for Neonatal Encephalopathy Trial) register (see the University of Oxford National Perinatal Epidemiology Unit Toby Cooling Register).

When to stop

In a newly-born baby with no detectable cardiac activity, and with cardiac activity that remains undetectable for 10 min, it is appropriate to consider stopping resuscitation. The decision to continue resuscitation efforts beyond 10 min with no cardiac activity is often complex and may be influenced by issues such as the presumed aetiology of the arrest, the gestation of the baby, the presence or absence of complications, and the parents' previous expressed feelings about acceptable risk of morbidity.