Neonatal Resuscitation

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1. Introduction:
Effective resuscitation of the newborn infant requires adequate training and preparation of staff involved in the care of women in labour, knowledge of maternal and intrapartum risk factors that may influence the postnatal course of the infant, and adequate and functioning equipment for resuscitation of the newborn. "As poor cardiorespiratory adaptation at birth (low Apgar scores) cannot be predicted in the majority of cases, all staff involved in care during labour should be skilled in resuscitation of the newborn".  

2. Incidence and risk factors:
Need for resuscitation: In 2009 in Australia, a total 294,540 women gave birth to 299,220 babies. There were 296,791 live births and 2,341 fetal deaths. 8.2% of babies were born preterm (before 37 completed weeks of gestation) and 0.9% post-term (42 weeks gestation or more). Most women (68.5%) had a vaginal birth, and of these, 82.9% did not involve the use of instruments. Overall, 31.5% of women gave birth by caesarean section. Overall, 6.2% of live born babies were of low birth weight (less than 2,500 grams). Less than 1.5% of live born babies had a low Apgar score. The perinatal death rate was 9.8 per 1,000 births in 2009, which comprised fetal and neonatal death rates of 7.8 per 1,000 births and 3.0 per 1,000 live births respectively.

Suction and oxygen therapy were the most common types of resuscitation used. Just over one-quarter (28.1%) of babies required some form of resuscitation at birth, although most of these babies (71.3%) required only suction or oxygen therapy. Ventilatory assistance by intermittent positive pressure respiration (IPPR) through a bag and mask or after endotracheal intubation was performed for at least 7.2% of all live births. External cardiac massage and ventilation was provided for a minority of babies (0.3%).

Antenatal prediction of need for resuscitation: only about half of the infants needing resuscitation are predicted by antenatal history or signs during labour. International guidelines on neonatal resuscitation and College guidelines
state that an appropriately trained practitioner should be present at all births (including caesarean section) and an advanced skills practitioner present for high risk deliveries. Assessment should include a history of maternal and intrapartum risk factors that may affect the infant including pre-existing medical conditions in the mother, problems of pregnancy, abnormalities identified antenatally in the fetus, the presence of meconium stained liquor, CTG abnormalities, scalp pH or lactate, maternal indicators of infection, presentation and method of delivery.

**Neonatal medical/tNNP staff should attend all high-risk deliveries including:**
- Preterm infants <35 weeks gestation
- Multiple births
- Infants with significant congenital malformation diagnosed antenatally
- Abnormal CTG or scalp pH < 7.21 or scalp lactate > 4.2 mmol/L
- Thick (particulate) meconium stained liquor
- Breech delivery
- Instrumental delivery (not uncomplicated low forceps or vacuum lift-out)
- Caesarean section under general anaesthetic
- Emergency caesarean section
- Opioids administered to the mother within 4 hours of delivery
- Other situations where there is concern of infant compromise

**Deliveries requiring attendance of an advanced skills practitioner - HDU registrar / tNNP:**
- All those requiring neonatal medical / tNNP staff attendance until their basic resuscitation training is assessed as competent.
- Delivery <33 weeks gestation
- Category 1 and 2/30° urgent caesarean sections
- Thick (particulate) meconium stained liquor present in early labour or associated with abnormal CTG or scalp pH < 7.21 or scalp lactate > 4.2 mmol/L
- Known maternal condition or fetal abnormality with potential to affect adaptation
- Other situations where there is concern of infant compromise

**Deliveries requiring attendance of neonatal Fellow or Consultant on duty:**
- Delivery <30 weeks,
- Prolonged fetal bradycardia (<100 for >5 minutes),
- Known severe fetal abnormality
- Other situations as requested by obstetric or neonatal staff

### 3. Consequences:
Complications of neonatal resuscitation: reported complications from appropriately applied resuscitative techniques are uncommon in neonates and infants. The potential benefits of appropriately applied resuscitative techniques far outweigh any potential harm. Infants should be surveyed for potential injury post resuscitation particularly airway injury after difficult intubation attempts and rib and organ injury after chest compressions.

### 4. Equipment needed for resuscitation
This should be functionally checked immediately before all newborn resuscitation. (Remember **Heat Oxygen Light Suction**).

1. Radiant warmer
2. Pulse oximeter and probe
3. Warm towel and blankets
4. Polyethylene wrap for infants <28 weeks or <1500g
5. An interruptible t-piece – Neopuff is the primary method of IPPV for resuscitation at RPA: preset peak inspiratory pressure (PIP) 20 cmH₂O; end expiratory pressure (EEP) 5 cmH₂O [relief valve maximum pressure 40 cmH₂O].
6. Resuscitation bag and mask:
   - All resuscitaires should have a self-inflating bag (infant Laerdal) which needs a reservoir attached to deliver more than 40-60% oxygen. The ‘pop-off’ valve (set at 35cmH₂O) varies greatly in maximal pressure delivered before the valve automatically opens. They do not provide positive end expiratory pressure.
   - The resuscitation mask should comfortably cover the mouth and nose whilst sitting on top of the chin. Circular silicone masks result in less air-leak and are easier to clean.
7. Endotracheal tubes size 2.0, 2.5, 3.0, 3.5, 4.0 (see tube sizes and lengths)
8. Laryngoscopes (as a guide, size 00 for under 27/40s, 0 for 27/40s to 32/40s, 1 for infants over 32/40s)
9. Stethoscope
10. Pedi-Cap end-tidal CO₂ detector.
11. Oxygen source and tubing – use piped / wall oxygen / air with blender preferentially. Check oxygen / air bottles have adequate supply for transport.
12. Low flow suction source (set 100 mmHg), ³ tubing and size 10 FG Y-suction catheter and ‘meconium aspirator’.
13. Magill forceps for tracheal intubation (especially by the nasal route)
14. Surfactant administration - infant feeding catheter 3-5FG, tape measure, surfactant, 5 ml syringe and drawing up needle (see surfactant guidelines) as required
15. Meconium aspirator

In addition, the following equipment should be available, replaced after use and checked each shift:
1. Adrenaline 1:10 000 ampoule
2. Syringe and drawing up needles
3. Normal saline ampoule and normal saline fluid bag
4. Umbilical catheter (3.5 and 5 FG); linen tie; tape; 3-way tap
5. Dressing pack and sterile gloves

5. Algorithm for neonatal resuscitation

Figure.
a. Assessment at delivery:
Newborn infants who do not require resuscitation can generally be identified by a rapid assessment of the following 3 characteristics:4
- Term gestation?
- Crying or breathing?
- Good muscle tone?
If the answer to all 3 of these questions is “yes,” the baby does not need resuscitation and should not be separated from the mother. The baby should be dried, placed skin-to-skin with the mother, and covered with dry linen to maintain temperature. Observation of breathing, activity, and colour should be ongoing.4
Dry and stimulate the infant after delivery. The Apgar score\textsuperscript{16} is used to document postnatal adaptation at 1 and 5 minutes (and at 10, 15 and 20 minutes if < 8 at 5 minutes). It includes: Heart rate, respiratory efforts, tone, reflex irritability and colour guide resuscitation.

Assessment of heart rate should be done by intermittently auscultating the precordial pulse. When a pulse is detectable, palpation of the umbilical pulse can also provide a rapid estimate of the pulse and is more accurate than palpation at other sites.\textsuperscript{14}

Infants with low Apgar scores, or persisting cyanosis and/or bradycardia and/or irregular respiratory effort should receive assistance.\textsuperscript{4}

Infants with both blue (1\textsuperscript{O}) apnoea (apnoeic, flaccid and cyanosed with heart rate < 100 bpm; Apgar score = 1), and white (2\textsuperscript{O}) apnoea (apnoeic, flaccid and pallid with heart rate < 100; Apgar score = 1) can be recognised almost immediately after birth\textsuperscript{17,18} and resuscitation commenced without delay.

b. Minimize heat loss:
Prevention of cooling reduces the mortality of low birth weight infants.\textsuperscript{19-24} Infants gain and lose heat by 4 modalities: evaporation, radiation, convection and conduction. Steps taken in the delivery room to prevent heat loss that have been shown to be effective include:
1. If resuscitation is not required - early skin to skin contact with mother under warm blankets in term infants.\textsuperscript{25,26}
2. Dry the infant (and wrap in warm blankets when resuscitation completed)
3. Radiant heater
4. Polyethylene wrap for infants <28/40s or <1500g\textsuperscript{25} (see thermoregulation guideline)
5. Plastic covering when moving the resuscitaire.

Avoid overheating, particularly with infants wrapped in polyethylene under radiant heaters. Infant temperature should be monitored carefully as soon as the infant is stabilised with initial resuscitation. Hyperthermia has been associated with exacerbation of cerebral injury following ischaemic injury in animal studies; infants born to febrile mothers have been found to have an increased risk of death, respiratory depression, seizures and cerebral palsy.\textsuperscript{27}

In term asphyxiated infants, therapeutic cooling improve outcome reducing mortality and disability.\textsuperscript{28} If an infant meets criteria for cooling, this should be discussed after initial stabilisation. See Moderate systemic hypothermia for the treatment of neonatal hypoxic ischaemic encephalopathy (HIE) guideline. If the baby is not cooled, overheating should be avoided.

c. Suctioning of the airway:
There is no evidence to support routine suctioning of the upper airway or stomach in newborn infants and reports of injury indicate the potential for harm.\textsuperscript{15,29} Suctioning of the upper airways should be restricted to who have obvious obstruction to spontaneous breathing.

Meconium stained liquor:
- Suctioning as the head delivers when meconium is present is no longer routinely recommended as a large multicentre randomised trial has shown this makes no difference to outcome.\textsuperscript{30} However if thick meconium appears to be in the mouth causing obstruction, it should be suctioned out.
- Suctioning below the cords when thick meconium is in the liquor:
  - In the absence of randomized, controlled trials, there is insufficient evidence to recommend a change in the current practice of performing endotracheal suctioning of non-vigorous babies with meconium-stained amniotic fluid. However, if attempted intubation is prolonged and unsuccessful, bag-mask ventilation should be considered, particularly if there is persistent bradycardia.\textsuperscript{29}
  - If the baby is vigorous and breathing established, do not attempt to suction below the cords – as there is evidence that this does not reduce the incidence or severity of meconium aspiration and may do harm.\textsuperscript{31}

d. Assisted ventilation:
Effective ventilation is the most important part of neonatal resuscitation in an infant that has not established regular breathing and good heart rate following initial drying and stimulation.
- In an RCT, there was no significant difference in SpO\textsubscript{2} at 5 minutes after birth in infants < 29 weeks gestation given PPV with a T-piece or a self inflating bag.\textsuperscript{32}
Start with interrupted t-piece intermittent positive pressure ventilation (IPPV):

- The mask should cover the mouth and nose, but not be as high as the eyes and it should sit below the mouth on the chin. There should be a good seal. The head position should be neutral or ‘sniffing’ (not overly extending the neck), with jaw thrust if needed to help open the airway.
- Ventilate at 30 – 60 breaths per minute PIP 20 cmH\textsubscript{2}O EEP 5 cmH\textsubscript{2}O.\textsuperscript{29}
- If heart rate and colour do not improve with mask IPPV, check that the airway is adequate (appropriate head position) and the seal of the mask is good, and that the chest is moving – higher inflation pressures may be needed. If mask IPPV is not producing a response, intubation could be attempted. Call for assistance.
- Although current neonatal resuscitation guidelines recommend using visual assessment of chest wall movements to guide the choice of inflating pressure during positive pressure ventilation, observers tended to underestimate tidal volume by 3.5mL and agreement between clinical assessment and measured V(\text{Te}) was generally poor.\textsuperscript{33}

Oxygen use with ventilation (IPPV and mask or via endotracheal tube):

- Oximetry should be used when resuscitation can be anticipated, when positive pressure is administered for more than a few breaths, when cyanosis is persistent, or when supplementary oxygen is administered.\textsuperscript{34} Place a pulse oximeter on the right arm/hand (preductal Sp\textsubscript{O}\textsubscript{2}). Applying the sensor to the infant before connecting it to the cable yields the fastest acquisition of accurate HR data.\textsuperscript{35}
- Preaductal targeting of Sp\textsubscript{O}\textsubscript{2} should approximate physiological levels – see ‘targeted preductal Sp\textsubscript{O}\textsubscript{2} after birth’ Figure ‘Newborn Resuscitation Algorithm’.

- For term and near term infants (32-36 weeks weeks): Start in air and adjust clinically as needed – increasing after 30 seconds if there is a poor response, and decreasing as able as colour/oxygen saturations improve (see below).
  - Conflicting meta-analyses come to different conclusions regarding evidence for use of air versus oxygen for initial resuscitation.\textsuperscript{36, 37} Meta-analysis of 8 controlled trials (1,500 patients) reported the evidence is based mainly on quasi-randomized studies with unblinded resuscitators and found no significant difference in death (RR 1.35, 95\%CI 0.97 to 1.88; P = 0.08), hypoxic/ischemic encephalopathy (RR 1.03, 95\% CI 0.86 to 1.23; P = 0.74), or requiring tracheal intubation was (RR 0.85, 95\% CI 0.69 to 1.05; P = 0.12).\textsuperscript{37}
  - For very preterm infants 9<32 weeks): Start in 30-40\% Fi\textsubscript{O\textsubscript{2}} and adjust clinically as needed – increasing after 30 seconds if there is a poor response, and decreasing as able as colour/oxygen saturations improve (see below).
  - Titrating from an initial oxygen concentration of 100\% was more effective than giving a static concentration of 100\% oxygen in maintaining preterm infants in a target oxygen saturation range.\textsuperscript{38} Initiating resuscitation with 21\% oxygen resulted in a high treatment-failure rate.\textsuperscript{39, 40} However, Use of oximetry targeting allows for physiological targeting of oxygen in preterm infants with small trials suggesting starting at 30\% instead of 90\% and titrating results in appropriate Sp\textsubscript{O}\textsubscript{2} targeting in most infants.\textsuperscript{40, 41}
  - A preliminary meta-analysis\textsuperscript{42} of trials of lower versus higher early Sp\textsubscript{O}\textsubscript{2} targeting found higher survival rates at 36 weeks’ postmenstrual age in infants born <28 weeks of gestation and randomly assigned to oxygen saturation (Sp\textsubscript{O}2) targets of 91 to 95\% rather than 85 to 89\% while breathing supplemental oxygen. Until longer-term data on survival and morbidity are available, it is prudent not to target a Sp\textsubscript{O}2 85 to 89\% in infants born earlier than 28 weeks of gestation.\textsuperscript{42}

\textbf{e. Tracheal intubation:}

Indications for endotracheal tube intubation include:

- Tracheal suctioning for meconium if infant born through thick meconium and non-vigorous (no respiratory effort)\textsuperscript{4}
- Failure to provide adequate ventilation using a bag and mask despite adequate attempts at obtaining an airway\textsuperscript{4}
- Prophylactic surfactant (infants born <27 weeks gestation)\textsuperscript{43} (see surfactant guidelines)
- Respiratory distress\textsuperscript{44, 45} likely to require continued ventilatory support (see surfactant guidelines)
- Congenital abnormalities as indicated (eg diaphragmatic hernias)\textsuperscript{4}

Endotracheal tube size and placement: see guide to ETT size and distances based on infant weight (see ETT size and length chart). ETT 2.5 can be used for infants up to 1.4kg; ETT 3.0 1.0 -2.0kg; ETT 3.5 1.9 – 3.7kg; ETT 4.0 - 3.7kg+.

\textbf{Checking position of the ETT:}

- Ensure you see the ETT going through the cords; insert to 2cm (slightly less in infants <750g) which is the end black mark (2cm).
- A PediCap or respiratory function monitor can be used to assist in assessing ETT placement.
An observation study reported both methods correctly identified successful ETT placement in 21/35 (60%) intubations, in 3 (9%) both indicated the ETT was not in the trachea, in the remaining 11 (31%) the PediCap failed to change colour despite the flow wave indicating correct ETT placement. Colorimetric CO₂ detectors may fail to change colour in spite of correct tube placement in up to one third of the cases.

- Listen for air entry in each side of the chest; if the tube is too far down (usually it would be down the right main bronchus) there will be decreased breath sounds on the unventilated side (usually the left) – withdraw the ETT until breath sounds are equal. No single technique is without limitations and clinicians should utilize a combination.
- If there is doubt as to whether it is in the trachea despite the measures above, look again with a laryngoscope to see if the tube is through the cords.

### f. Combined external cardiac compression and assisted ventilation

- Check for pulse: either by auscultation, palpating umbilical arteries or apex beat.
- Perform cardiac massage: if initial heart rate after initiation of ventilation is < 60-bpm or remains 60-80 bpm after initiation of adequate ventilation.

#### Chest compression:
- Compressing the lower half of sternum either by:
  - Encircle the chest with both hands and use 2 thumbs (higher blood pressure and better coronary perfusion in pigs) – preferred method; or by:
  - Using 2 fingers over the lower sternum. The 2-finger technique may be preferable when access to the umbilicus is required during insertion of an umbilical catheter.
  - Avoid the chest margins and xiphisternum and do not restrict chest re-expansion.
- Compress the chest 1/3rd of its depth

#### Provide chest compression in combination with ventilation:
- There should be at least 90 compressions and 30 breaths per minute, with a ratio of 3 compressions with 1 breath (ie 3:1 ratio: c-c-c-v-c-c-v-c-c-c-v).

### g. Assess the response

- Reassess the response to ventilation every 30-60 seconds
- Continue to ventilate until there is an adequate response – crying or adequate sustained spontaneous breathing and heart rate > 100 bpm
- With infants receiving coordinated chest compressions and ventilations, Respirations, heart rate, and oxygenation should be reassessed periodically, and coordinated chest compressions and ventilations should continue until the spontaneous heart rate is ≥ 60 per minute.
- Frequent interruptions of compressions should be avoided, as they will compromise artificial maintenance of systemic perfusion and maintenance of coronary blood flow.

### h. Failure to respond to resuscitation

- If there is an initial heart beat this is usually due to inadequate ventilation
  - If bag and mask ventilation: ensure an adequate airway (chin lift and slight head tilt)
  - Failure to respond to bag and mask ventilation is an indication for intubation.
  - If endotracheal tube: usually a misplaced endotracheal tube (ie oesophageal). See Checking position of the ETT.
  - If the above have been checked and optimised and there is inadequate response, then there may be blocked endotracheal tube, blocked airway or severe lung disease. Change tube under suction.
  - Preterm infants with surfactant deficiency may respond to surfactant treatment.
  - Deterioration after initial response to resuscitation may indicate a misplaced endotracheal tube or air leak.
  - Consider the possibility of anatomical anomalies or pleural effusions (suggested by antenatal findings).
- If none of the above then increase ventilatory effort and follow Newborn Resuscitation Algorithm
- Call for assistance

### i. Vascular access

- Use umbilical vein where possible,
- Alternative routes include: peripheral vein (eg scalp vein), femoral vein, or endotracheal (ETT) routes for adrenaline.
The umbilical artery and subclavian veins should be avoided where possible due to the potential complications of these routes.

6. Drugs in resuscitation:

Summary:
- Adrenaline is the most commonly used drug in newborn resuscitation and is included in the ILCOR resuscitation algorithm. However, its reported use is for <1 per 1000 deliveries.
- Hypovolaemia is difficult to diagnose but must be considered in specific situations and when there is a failure of response to resuscitation measures despite adequate ventilation. Volume expansion (normal saline or blood) is reported in 1 per 12 000 deliveries.
- The other agents are rarely indicated for newborn resuscitation but may have a roll in post-resuscitation care.

a. Adrenaline:
The recommended IV dose is 0.01 to 0.03 mg/kg per dose. Higher IV doses are not recommended because animal and paediatric studies show exaggerated hypertension, decreased myocardial function, and worse neurological function after administration of IV doses in the range of 0.1 mg/kg.

If the endotracheal route is used, doses of 0.01 or 0.03 mg/kg will likely be ineffective. Therefore, IV administration of 0.01 to 0.03 mg/kg per dose is the preferred route. While access is being obtained, administration of a higher dose (0.05 to 0.1 mg/kg) through the endotracheal tube may be considered, but the safety and efficacy of this practice have not been evaluated.

Dosage regimen used at RPA:
1. Adrenaline 0.03 mg/kg intravenously via UVC = 0.3 ml/kg of 1:10000 adrenaline, or
2. If unable to obtain rapid venous access give: adrenaline 0.1 mg/kg via ETT = 1 ml/kg of 1:10000 adrenaline.

Repeat dose once if no response after 60 seconds.

b. Naloxone:
This should only be considered in infants who are depressed by opiates once an infant has first been stabilised with ventilatory support, and has good heart rate and colour.

DO NOT give Naloxone to infants of narcotic dependent mothers. It can precipitate acute withdrawal.

Opiates given to the mother in labour (within 4 hours of delivery), can affect the infant’s drive to breathe at the time of delivery, and possibly in the first few hours of life. If a mother has received Pethidine, the infant needs close observation for at least the first 4 hours of life (see Observation And Management Of Newborn Infants With Respiratory Maladaptation To Birth, Including Infants Exposed To Intrapartum Opioids Administered To The Mother During Labour Policy). It is yet to be demonstrated that use of Naloxone in opiate exposed newborns can reduce the need for admission to NICU or mechanical ventilation. The half life of Naloxone is shorter than pethidine, so close observation is particularly important in infants who have received this to ensure apnoea does not occur as the effect of Naloxone wears off.

Dose: Naloxone 100 µg/kg via intravenous or intramuscular injection (preferred). For term or near term infants, if weight is not known, then give 0.5ml of Naloxone 400µg/ml (ie 200µg).

Naloxone is quick acting and should work within a couple of minutes of giving it. Effect after giving this IM is only slightly delayed compared with IV.

c. Bicarbonate:
A single trial of intravenous infusion of sodium bicarbonate to newborn babies during resuscitation in the delivery room at birth did not show any benefit of the use of this drug immediately after birth, nor any adverse effects.

- Bicarbonate should be restricted to post-resuscitation correction of acidosis. See acidosis guideline.
- Obtain an early blood gas after resuscitation.
- If there is a significant metabolic acidosis the dose is: 4.2% NaHCO₃ ml = 0.3 x weight kg x BE given over 30-60 minutes.
d. Dextrose:
Glucose has not been shown in animal models or adult humans to change the outcomes of cardiopulmonary resuscitation. No trial of glucose versus no glucose for resuscitation exists for neonates.

Neonates requiring CPR should have an early blood sugar estimate after resuscitation and correction of hypoglycaemia if BSL < 2.0 mmol/L (see hypoglycaemia guideline).

e. Calcium and Atropine:
There is no evidence to support the use of these agents during neonatal resuscitation.

7. Volume replacement in resuscitation:
Hypovolaemia is difficult to diagnose in the neonate. Volume expansion should be considered when blood loss is known or suspected (pale skin, poor perfusion and weak pulse) and the baby’s heart rate has not responded adequately to other resuscitative measures. An isotonic crystalloid solution or blood is recommended for volume expansion in the delivery room.

Significant hypovolaemia should be strongly considered in the following situations:
- Pale infant with tachycardia, especially if preceded by
  - Vasa praevia or
  - Feto-placental haemorrhage (when there is cutting of a nuchal cord on delivery of the head and the cord is cut before placenta-fetal transfusion can occur after delivery), or
  - Feto-maternal haemorrhage. Suspect if sinusoid CTG trace and/or raised middle cerebral artery peak systolic velocity on fetal ultrasound. Order maternal QFMH.
  - Placental trauma (accidents and at caesarean when cutting through an anterior placenta with subsequent delayed delivery)
  - Acute twin-twin transfusion with uterine contractions
- Note - Uterine rupture, antepartum haemorrhage and placental abruption is usually associated with fetal hypoxia and blood loss is commonly maternal.

Treatment:
- Early and adequate blood volume replacement may improve outcome in fetal haemorrhagic shock. Give whole blood or packed red cells in 20 ml/kg aliquots titrated against response. Serial haematocrit may be used to determine adequacy of red cell replacement. Note initial haematocrit may be normal with acute blood loss.
- If hypovolaemia / poor output is suspected but blood is not immediately available: give Normal Saline 10-20 ml/kg over 10-30 minutes and titrate against response. There are no data to suggest that albumen or other volume expanders are superior to normal saline in hypotensive infants.

Arrhythmias in neonates: these are rarely a primary problem at neonatal resuscitation. See arrhythmia and hyperkalaemia guidelines.

8. Cord Blood Sampling:
A cord gas should be taken for every baby who requires resuscitation. Take blood from an umbilical artery. There are two umbilical arteries that are smaller, muscular and blue (compared with one larger purple coloured umbilical vein). Sample from the placental surface if necessary (arteries go over the veins). An umbilical venous-arterial pH difference of 0.15 is an effective cutoff value in differentiating cord prolapse from abruptio placentae (accuracy 92%).

Normal values for cord gases:

<table>
<thead>
<tr>
<th>Umbilical artery</th>
<th>Umbilical Vein</th>
</tr>
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<tbody>
<tr>
<td>pH: 7.24 ± 0.07 [range 7.37 – 7.10]</td>
<td>pH: 7.32 ± 0.06 [range 7.43 – 7.20]</td>
</tr>
<tr>
<td>BE: -5.6 ± 3.0 mmHg [range +0.3 to -11.5]</td>
<td>BE: -4.5 ± 2.4 mmHg [range +0.2 to -9.2]</td>
</tr>
</tbody>
</table>

Measures of hypoxia:
- pH <7.0 (important for diagnosis of HIE)
- pH <7.10 (2SD below normal)

- Sample before 30 minutes from a clamped cord
A blood gas is stable in syringe for 30 minutes
With delayed sampling placental pH values fall at twice the rate as umbilical pH values. 63

9. Management after resuscitation (see asphyxia guideline):
- Seek the cause of the arrest and treat specifically.
- Complications of the resuscitation procedure should be sought, including air leaks (pneumothorax, pneumomediastinum or pneumopericardium), oesophageal injury and blood loss from organ damage (eg liver).
- Obtain cord arterial and venous blood gas analysis (may be obtained from placental vessels - arteries cross veins).
- Perform Apgars at 1 and 5' and every 5' until Apgar > 7.
- Document time to sustained spontaneous respiration.
- Obtain early arterial blood gas and BGL. Correct persisting acidosis and hypoglycaemia.
- Respiratory support: continue ventilation till adequate sustained spontaneous respiration and without severe respiratory distress. Ventilate to ensure adequate oxygenation and normocarbia.
- Monitor vital organ function: cardiac dysfunction as determined by hypotension or poor cardiac output (ECHO); renal dysfunction (oliguria < 0.5 ml/kg/hour or creatinine 120mmol/L); hepatic dysfunction (abnormal LFTs); and cerebral dysfunction (hypoxic ischaemic encephalopathy and seizure).
- Avoid running high fluid rates in asphyxiated infants, as fluid retention may occur resulting in hyponatraemia.
- Monitor electrolytes.

10. Cessation of cardiopulmonary resuscitation:
The decision to cease cardiopulmonary resuscitation should be based on cause of arrest, response to resuscitation, and remediable factors.

Death or severe neurological abnormality is predicted by a failure to obtain a heart rate by 10 minutes (Apgar score 0 at 10') despite adequate resuscitation and failure to respond to adrenaline.

A search of the literature has failed to reveal a single infant with Apgar score of 0 at 10 minutes who was normal at follow up with the majority not able to be resuscitated or becoming a neonatal death. 6

11. Key Points

<table>
<thead>
<tr>
<th>Key Point</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newborn infants who do not require resuscitation can generally be identified by a rapid assessment of the following 3 characteristics: Term gestation; Crying or breathing; Good muscle tone. If the answer to all 3 is “yes,” the baby does not need resuscitation and should be dried, placed skin-to-skin with the mother, and covered with dry linen to maintain temperature.</td>
<td>LOE 5</td>
</tr>
<tr>
<td>If the infant is not term, crying or breathing or is floppy, the infant should be placed on a resuscitaire with radiant heater, dried and stimulated and assessed.</td>
<td>LOE 5</td>
</tr>
<tr>
<td>Normothermia is the goal.</td>
<td>LOE 5</td>
</tr>
<tr>
<td>a. Hypothermia is associated with worse outcome in premature babies</td>
<td>LOE 1a</td>
</tr>
<tr>
<td>b. Hyperthermia exacerbates ischaemic cerebral injury.</td>
<td>LOE 2</td>
</tr>
<tr>
<td>c. Use polyethylene wrap for premature babies under 28 weeks gestation</td>
<td>LOE 1a</td>
</tr>
<tr>
<td>A person who is able to initiate basic life support should be present at every delivery. A person capable of advanced resuscitation should be present if there are risk factors for the infant to be compromised.</td>
<td>LOE 5</td>
</tr>
<tr>
<td>Suctioning the oropharynx/nasopharynx is not routinely needed, including when liquor is meconium stained. However, suction if there is obstruction of the airway.</td>
<td>LOE 1b GOR A</td>
</tr>
<tr>
<td>Do not suction below the cords when meconium is present if the baby is vigorous and breathing spontaneously.</td>
<td>LOE 1a GOR A</td>
</tr>
<tr>
<td>If the infant is born through thick meconium and is floppy and not breathing, consider suctioning the trachea. However, if attempted intubation is prolonged and unsuccessful, bag-mask ventilation should be instituted, particularly if there is persistent bradycardia.</td>
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<td>Ventilation is the most important part of advanced resuscitation, and the majority of babies will respond to this alone.</td>
<td>LOE 5</td>
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</table>
If intermittent positive pressure ventilation is required:
- In term and near term infants (≥32 weeks gestation) start in air (21% oxygen) and titrate to physiological preductal SpO₂ (see algorithm)
- In very preterm infants (<32 weeks) start in 30% oxygen and titrate to physiological preductal SpO₂ (see algorithm). Do not give supplementary oxygen if SpO₂ >95%.

If the heart rate is <60 bpm, correct ventilation and commence 3:1 cardiac compressions : breath using encircling method. Rate 120 events per minute. Reassess every 30 seconds and stop compressions when heart rate >60 bpm or infant has return of tone, breathing or circulation.

Adrenaline 0.03 mg/kg intravenously via UVC = 0.3 ml/kg of 1:10000 adrenaline, or
If unable to obtain rapid venous access give: adrenaline 0.1 mg/kg via ETT = 1 ml/kg of 1:10000 adrenaline

12. References

44. Stevens TP, Harrington EW, Blennow M, Soll RF. Early surfactant administration with brief ventilation vs. selective surfactant and continued mechanical ventilation for preterm infants with or at risk for respiratory distress syndrome. Cochrane database of systematic reviews. 2007:CD003063.


Revised: January 2012

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