Neonatal Resuscitation

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Asphyxia - The Basics

- **Apnea**
- The asphyxiated infant passes through a series of events:
  - rapid breathing and fall in heart rate
  - primary apnea
  - irregular gasping, further fall in heart rate and drop in blood pressure
  - secondary apnea
- Most infants in primary apnea will resume breathing when stimulated. Once in secondary apnea, infants are unresponsive to stimulation.
- Apnea at birth should be treated as secondary apnea of unknown duration (i.e. began in utero) and resuscitation should begin at once.

Clearing Fetal Lung Fluid

- The first few breaths of a normal infant are usually adequate to expand the lungs and clear the alveolar lung fluid.
- The pressure required to open the alveoli for the first time may be two to three times that for normal breaths.
- Expect problems in lung fluid clearance with:
  - apnea at birth
  - weak initial respiratory effort caused by:
    - prematurity
    - depression by asphyxia, maternal drugs, or anaesthesia

Pulmonary Circulation

- At birth, pulmonary blood flow increases rapidly as the lung arterioles open up and blood is no longer diverted through the ductus arteriosus.
- With asphyxia, hypoxemia and acidosis perpetuate pulmonary vasoconstriction and maintain the fetal pattern of circulation.

Systemic Circulation and Cardiac Function

- Early in asphyxia, vasoconstriction in the gut, kidneys, muscles and skin redistributes blood flow to the heart and brain as an attempt to preserve function.
- With progressive hypoxemia and acidosis, myocardial function deteriorates and cardiac output declines

Preparation for Delivery

- **Anticipate Need for Resuscitation**
- Antepartum and intrapartum history may help to alert delivery-room staff about the possibility of a depressed or asphyxiated newborn.

Antepartum Factors

- Age > 35 years
  Maternal diabetes
  Pregnancy-induced hypertension
  Chronic hypertension
  Other maternal illness
  (e.g. CVS, thyroid, neuro)
  Previous Rh sensitization
  Drug therapy e.g. magnesium, lithium adrenergic-blockers
  Maternal substance abuse
  No prenatal care
  Previous stillbirth
  Bleeding - 2nd/3rd trimester
  Hydramnios
  Oligohydramnios
  Multiple gestation
  Post-term gestation
  Small-for-dates fetus
  Fetal malformations

Intrapartum Factors

- Abnormal presentation
  Operative delivery
  Premature labour
  Premature rupture of membranes
  Precipitous labour
  Prolonged labour
  Indices of fetal distress
  (FHR abnormalities, biophysical profile)
  Maternal narcotics
  (within 4 hrs of delivery)
  General anaesthesia
  Meconium-stained fluid
  Prolapsed cord
  Placental abruption
  Placenta previa
  Uterine tetany

Personnel

- At every delivery, at least one individual should be capable of performing a complete resuscitation (i.e. including endotracheal intubation and the use of medications). In many cases, this is the person delivering the infant.
- A second person who will be primarily responsible for the infant, must be present in the delivery room as well, even for cases when a normal infant is expected. This person must be able to initiate a resuscitation and if a complete resuscitation becomes necessary, assist the fully-trained person.

- When neonatal asphyxia is anticipated, two individuals whose sole responsibility is to the infant, should be present in the delivery room and be prepared to work as a team to perform a complete resuscitation. The person delivering the mother must not be considered as one of the two resuscitators.
- With multiple births, a team is needed for each infant.
- There should be no delay in initiating resuscitation; waiting a few minutes for someone "on-call" to arrive is an unacceptable practice and invites disaster.

Equipment

- Equipment and medications should be checked as a daily routine and then prior to anticipated need. Used items should be replenished as soon as possible after a resuscitation.
- The delivery room should be kept relatively warm and the radiant heater should be preheated when possible. Prewarming of towels and blankets can also be helpful in preventing excessive heat loss from the neonate.

Resuscitation Equipment in the Delivery Room

- Radiant Heater
  Stethoscope
  ECG monitor
  Wall oxygen with flowmeter and tubing
  Neonatal resuscitation bag
  (with manometer)
  Face masks, Oral airways:
  - newborn and premature
  Medications:
  - Epinephrine (1:10,000)
  - Naloxone (0.4 or 1 mg ? ml-1)
  - Volume expander
  - Sodium bicarb (0.5mEq ? ml-1) Suction with manometer
  Bulb syringe
  Suction catheters:
  - 5F or 6F, 8F and 10F
  Endotracheal tubes:
  - 2.5, 3.0, 3.5, and 4.0 mm
  ET tube stylet
  Laryngoscope with straight blades:
  - No. 0 & 1
  Umbilical vessel catheterization tray
  Umbilical catheters:
  - 3.5 & 5F
  Needles, syringes
  Feeding tube 8F + syringe

Initial Stabilization

- **Prevent Heat Loss**
- Place the infant under an overhead radiant heater to minimize radiant and convective heat loss.
- Dry the body and head to remove amniotic fluid and prevent evaporative heat loss. This will also provide gentle stimulation to initiate or help maintain breathing.

Open the Airway

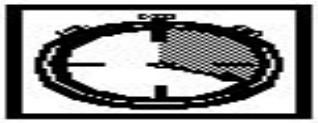
- Position the infant supine or on his or her side with the neck either in a neutral position or slightly extended. Avoid overextension or flexion which may produce airway obstruction. A slight Trendelenburg position may also be helpful.
- A folded towel (approximately 2.5 cm thick) placed under the infant's shoulders may be useful if the infant has a large occiput.
- If the infant has absent, slow or difficult respirations, apply suction first to the mouth and then nose. If the nose were cleared first the infant may gasp and aspirate secretions in the pharynx. If mechanical suction with an 8F or 10F catheter is used, make sure the vacuum does not exceed -13.3 kPa (-100 mmHg). Limit suctioning to 5 seconds at a time and monitor heart rate for bradycardia which may be associated with deep oropharyngeal stimulation.
- If meconium is present in the amniotic fluid, special suctioning may be required in the depressed infant.

Tactile Stimulation

- If drying and suctioning do not induce effective breathing, additional safe methods include:
  - slapping or flicking the soles of the feet
  - rubbing the back gently
- Do not waste time continuing tactile stimulation if there is no response after 10 - 15 seconds.

Evaluate the Infant

- *Respirations*: Infants who are apneic or gasping despite brief stimulation attempts should receive positive-pressure ventilation. If there is adequate spontaneous breathing, go to next step.
- *Heart Rate*: Monitor either by auscultating the apical beat or by palpating the base of the umbilical cord. If the heart rate is below 100 bpm, begin positive-pressure ventilation, even if the infant is making some respiratory efforts. If the heart rate is above 100 bpm, go to the next step.
- *Colour*: The presence of central cyanosis indicates that although there is enough oxygen passing through the lungs to maintain the heart rate, the infant is still not well oxygenated. Free-flow 100% oxygen at 5 l$\cdot$min-1 using a mask held closely to the infant's face should be administered until the infant becomes pink, when the oxygen should be gradually withdrawn.



The steps in this section should take no longer than 20 seconds.

Place infant on preheated radiant warmer

Is thick or particulate amniotic fluid present?

Yes → **TRACHEAL SUCTIONING if infant depressed**

No

Dry amniotic fluid from body and head
Remove wet linen from contact with infant

Position infant with neck slightly extended

Suction mouth, then nose

Evaluate **Respirations**

Apneic / gasping → Slap foot, flick heel or rub back - 1-2 X's

Breathing

Evaluate **Heart Rate**

Breathing

Apneic gasping

100+ bpm

< 100 bpm → **BAG and MASK VENTILATION**

No HR → **INTUBATE+PPV CHEST COMP MEDICATIONS**

Evaluate **Colour**

Pink or peripheral cyanosis → Continue to observe infant

Central cyanosis → Provide free-flow oxygen (80-100%)

Ventilating Procedure

- When ventilatory support is required, most neonates can be adequately ventilated with a bag and mask. Positive-pressure ventilation (PPV) is indicated when:
  - apnea or gasping respiration is present
  - the heart rate is less than 100 beats / minute
  - central cyanosis persists despite 100 O2
- Ventilation should be adequate with 40 to 60 assisted breaths per minute. Initial lung inflation may require a pressure as high as 30-40 cm H2O but subsequent breaths should be in the 15-20 cm H2O range.

- Adequate ventilation is assessed by observing chest wall motion and hearing breath sounds bilaterally. If chest expansion is inadequate, the following steps should be followed in sequence:
- reapply the face mask to rule out a poor seal
- reposition the head - extend the head a bit further - reposition the shoulder towel
- check for secretions - suction if necessary
- try ventilating with the infant's mouth slightly open - perhaps with an oral airway
- increase pressure to 20-40 cm H2O
- abandon bag and mask - intubate trachea

- After 15-30 seconds of effective ventilation, the heart rate of the neonate should be evaluated. To save valuable time, the heart rate over a 6 second period is counted and multiplied by 10 to give an approximation of the 1-minute heart rate. (e.g. 8 beats in 6 seconds = 80 bpm)

The next step in the resuscitation depends on the heart rate which is determined

- **HR > 100**If spontaneous breath efforts are present, gradually reduce PPV and provide gentle tactile stimulation plus free-flow O2.
- **HR < 60**Immediately begin chest com- pressions and ensure that ventilation is adequate and that 100% O2 is being delivered.
- **60 < HR < 80 (not rising)**Continue ventilation and begin chest compressions.**60 < HR < 100 (rising)**Continue ventilation

Flow Chart: Ventilation

Equipment check:
- ✔ Resus Bag connected to O_2 - delivers 90-100%
- ✔ Resus Bag pressure tested - gauge working
- ✔ Appropriate size face mask selected

Adequate ventilation is established for 15-30 seconds, before the heart rate is assessed again.

Infant's head extended slightly (± head down tilt)
Mask covers chin, mouth & nose

Begin **PPV**
Observe for chest movement

Chest rises → Bag and mask ventilation effective

No chest rise → Reapply face mask to check seal → Check airway
- reposition head
- remove secretions
- mouth slightly open (? oral airway)

→ Increase ventilation pressure (20-40 cm H_2O)

→ **INTUBATE** Trachea

VENTILATE 15-30 secs
- rate: 40-60 breaths/min
- pressure: 15-20 cm H_2O

Check **Heart Rate** (use 6-second count)

HR > 100	**60 < HR < 100**	**HR < 60**
Look for Spont Vent	Continue PPV	Continue PPV
→ Withdraw PPV, Free-flow O_2, Tactile Stimuli, Monitor	→ **HR rising**: Continue PPV	→ Begin CHEST COMPRESSIONS
	→ **HR < 60 not rising**: Begin CHEST COMPRESSIONS	

Chest Compressions

- **Rationale**
- Asphyxia in the neonate not only slows the heart rate but also decreases myocardial contractility, resulting in diminished flow of blood and oxygen to vital organs. Chest compressions can temporarily increase circulation and oxygen delivery.
- Chest compressions must always be accompanied by ventilation with 100% oxygen.
- Pressing on the sternum compresses the heart and increases the intrathoracic pressure, causing blood to be pumped into the arterial circulation. Release of the sternal pressure will increase venous blood to return to the heart.

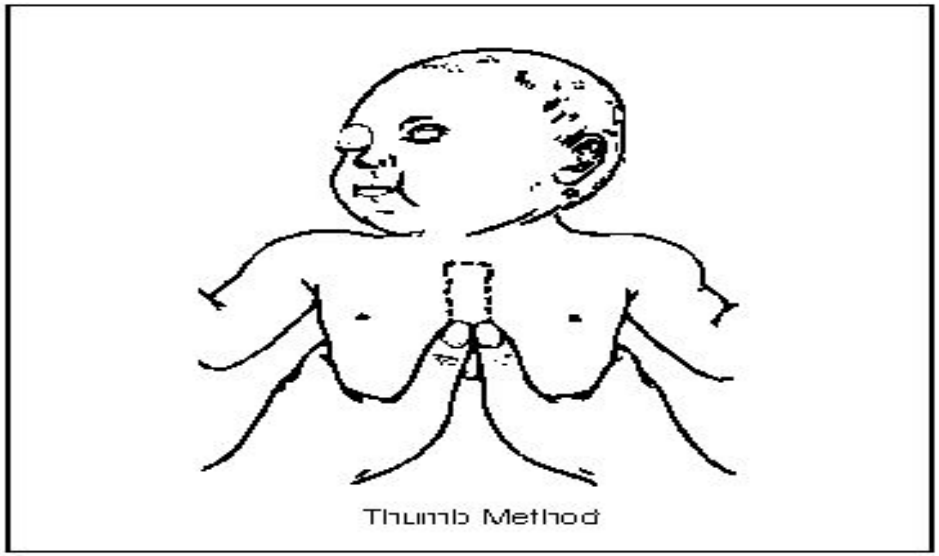
Indications

- *When to Begin Chest Compressions*:
  After 15-30 seconds of PPV with 100% O2 -
  - the heart rate is below 60 bpm
  - the heart rate is between 60 and 80 and not rising
- *When to Stop Chest Compressions*:
  - the heart rate is 80 bpm or greater

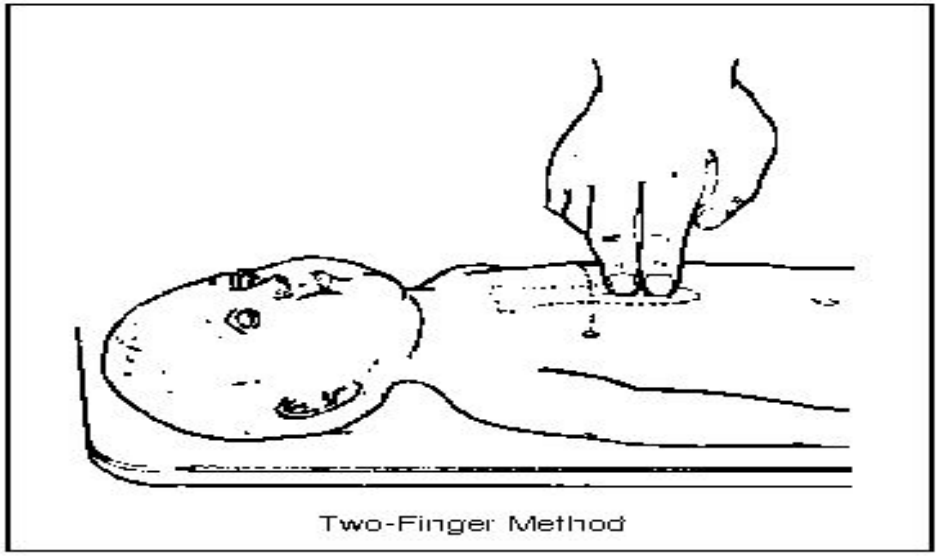
Technique

- *Location*: Pressure should be applied to the middle third of sternum, just below an imaginary line drawn between the nipples. Take care not to apply pressure to the xiphoid.
- *Pressure*: Use just enough pressure to depress the sternum 1.5 cm, then release the pressure to allow the heart to fill. One compression consists of the downward stroke plus the release.
- *Rate*: To match the heart rate of the normal neonate, the compress/release action should be repeated 120 times per minute (2 per second).

- *Thumb Method*: Encircle the torso with both hands and compress the sternum with both thumbs side-by-side while the fingers support the back. In very small neonates the thumbs may have to be superimposed. Use just the tips of the thumbs to compress to avoid squeezing the whole chest wall and fracturing ribs.
- *Two-finger Method*: This method is used if the resuscitator's hands are too small to encircle the chest properly or if access to the umbilicus is necessary for medications. The middle and ring fingers of one hand are held perpendicular to the chest and the tips apply pressure to the sternum while the other hand is used to support the back from below.



Thumb Method



Two-Finger Method

Evaluating the Heart Rate

- After the first 30 seconds of chest compressions, the heart rate should be checked.
- During the heart rate check, the chest compressions are interrupted for no more than the 6 seconds it takes to count the heart beats and make the calculation.
- If the infant is showing a positive response to the resuscitative efforts then one should check the heart rate every 30 seconds in order to stop chest compressions when the infant's own heart rate rises to 80 or above. Ventilation should be continued until the heart rate is above 100 bpm.
- Should the infant's heart rate remain below 80 bpm despite at least 30 seconds of adequate chest compressions and ventilation, resuscitation should progress rapidly to the next step of giving medications

Endotracheal Intubation

- **Indications**
- In most cases, when positive-pressure ventilation is required, it should be initiated with the bag and mask. Although some
- resuscitators will be very skilled at intubation, others with less experience may waste valuable time, delaying resuscitation.
- Endotracheal intubation is indicated in the following circumstances:
  - prolonged PPV required (to avoid gastric distension)
  - bag and mask ineffective (poor chest expansion, continuing low HR)
  - tracheal suctioning required (thick or particulate meconium)
  - diaphragmatic hernia suspected (prevent bowel distension in the chest)

Other Equipment

- *Laryngoscope*: Attach to the handle the appropriate size straight (Miller) blade: No. 0 for preterm infants and No. 1 for fullterm infants. Check that the bulb is screwed in tightly and then click the blade into position and ensure that the light is bright and does not flicker.
- *Suction Equipment*: Mechanical suction should be available and adjusted so that when the tubing is occluded the negative pressure does not exceed 13.3 kPa (100 mmHg). A suction catheter sized 10 F or larger should be present. Smaller catheters for suction through ET tubes should be available.
- *Resuscitation Bag and Mask connected to 100% O2*: The bag and mask should be handy to ventilate between intubation attempts or should intubation be unsuccessful. The bag itself will be used to ventilate through the ET tube.

Confirmation of ET Tube Placement

- If the ET tube is correctly placed in the mid-tracheal region, the following signs should be present:
  - air enters *both* sides of the chest (Listen in the axillae to avoid mistaking air entering the stomach for breath sounds.)
  - breath sounds are equal in intensity
  - symmetrical rise of the chest with each breath
  - *no* air heard entering the stomach
  - *no* abdominal distension
  - improvement in colour, heart rate and activity of the neonate
- A chest X-ray should be obtained for final confirmation if the tube is to stay in place beyond the initial resuscitation.

Complications of Intubation

- HypoxiaTaking too long to intubate Incorrect placement of tube

- Bradycardia/ApneaHypoxia
  Vagal response due to stimulation of posterior pharynx (laryngoscopy, suction)
- PneumothoraxExcessive pressure during ventilation or ET tube in right mainstem bronchus
- Contusions or Lacerations
  (tongue, gums,epiglottis, cords)Rough handling of laryngoscope or ET tube
  Laryngoscope blade too long or too short
- Perforation of trachea or esophagusInsertion of tube too vigorous or stylet protrudes beyond end of ET tube
- InfectionOrganisms introduced via equipment or hands

Tracheal Suction for Meconium Aspiration

- About one in eight deliveries are complicated by the presence of meconium in the amniotic fluid. Thorough suctioning of the nose, mouth and posterior pharynx before delivery of the shoulders does appear to decrease the risk of meconium aspiration and should be performed whether the meconium is thin or thick. A large-bore (12F or 14F) suction catheter should be used with mechanical suction.

- If meconium is present in an infant with respiratory difficulties, then immediately after delivery the posterior pharynx should be cleared under direct vision using a laryngoscope and suction catheter. If the meconium is thin and the newborn is vigorous, then tracheal suctioning is probably not required.
- If the neonate is depressed or the meconium is thick or particulate, then direct endotracheal suctioning should be performed. (See note #6)

- **Drugs and Fluids**
- For the majority of infants who require resuscitation, the only "medication" needed will be 100% oxygen delivered with effective ventilation. Some will require chest compressions. In only a very few infants will this next step be necessary.

- ***Epinephrine***:
- *Indications*:
  - - the heart rate stays below 80 despite effective ventilation with 100% oxygen and chest compressions for at least 30 seconds
  - - the heart rate is zero
- *Rationale*:
  - Epinephrine has both a- and b-adrenergic stimulating properties. The alpha effect causes vasoconstriction which raises the perfusion pressure during chest compressions, augmenting oxygen delivery to both heart and brain. The beta effect enhances cardiac contractility, stimulates spontaneous contractions and increases heart rate

    (1:10,000)1 ml0.01-0.03mg • kg-1
    (0.1-0.3 ml • kg-1)Give rapidly IV or ET
    Repeat q3-5 min
    (ET: dilute to 1-2 ml with NS

- ***Volume Expanders***:
- *Indications*:
  - Signs of hypovolemia. A 20% or greater loss in blood volume should be suspected when there is:
    - pallor persisting after oxygenation
    - a weak pulse despite a good heart rate
    - decreased blood pressure (under 55/30)
    - poor response to resuscitative efforts
- *Rationale*:
  - Hypovolemia occurs more frequently in the newborn than is commonly recognized. Blood loss is often not obvious and initial tests of hemoglobin and hematocrit are usually misleading. The increase in vascular volume secondary to a volume expander should improve tissue perfusion and reduce the development of metabolic acidosis.
  - NS or RL
    5% Albumin
    O-neg Blood40 ml10 ml ? kg-1Give IV over 5-10 min

- ***Naloxone***:
- *Indications*:
  - Naloxone is indicated in the infant for reversal of respiratory depression secondary to maternal opioids given within 4 hours prior to delivery.
- *Rationale*:
  - Naloxone is a pure opioid antagonist without intrinsic respiratory depression activity. It works very rapidly but attempts to give this drug should always be preceded by adequate ventilatory assistance. The duration of action of naloxone may be shorter than that of some opioids making continued respiratory monitoring mandatory for a further 4 to 6 hours.

(0.1 ml﷯kg-1)

Give rapid IV or ET preferred

- **Reserved for prolonged resuscitations only**
- Sodium Bicarbonate
  (0.5 mEq•ml-1 = 4.2% soln)
- 2 mEq • kg-1
  (4 ml • kg-1)Give slowly, over at least 2 min, IV ONLY, Infant must be ventilated

Postresuscitation Care

- Newborns who have been successfully resuscitated will require close monitoring in a neonatal intensive care unit or an area where special care by trained observers is possible.
- Postresuscitation care may include:
  - arterial pH and blood gas determinations
  - correction of documented metabolic acidosis
  - use of volume expanders and/or pressors if hypotension persists
  - appropriate fluid therapy
  - treatment of seizures
  - screening for hypoglycemia and hypocalcemia
  - chest X-rays for diagnostic purposes and ET tube position checks

- Complete documentation of all observations and actions should be entered in the infant's chart. This should include recording the APGAR scores calculated at one and five minutes.
- If the 5-minute APGAR score is less than 7, then additional scores should be obtained every 5 minutes for up to 20 minutes or until two successive scores are 8 or greater.
- Although the APGAR score is not used as a decision-making tool, it has been of value in assessing the progress of the resuscitation.