وزارة الصحة
Ministry of Health

Respiratory Care Bundle in the Neonate

Version 2 | December 2025

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Policy Title	Policy Number	Policy Issuer	Replacement of Policy Number
Respiratory Care Bundle in the Neonate	2		
Policy Classification	**Issue Date**	**Effective Date**	**Date of Next Revision**
○ Corporate Policy (General) ○ Inter-department Policy ○ Department Policy		01 – 09 – 2025	01 – 09 – 2028

1. Statement of Purpose

1.1 Respiratory distress is a major cause of admission to the Neonatal Intensive Unit; and the cause could be different disease and most of them remains a major cause of long-term morbidity and mortality.

1.2 This care bundle provides a framework for the management of neonates presenting with respiratory distress with the common diseases seen in the neonatal age group.

1.3 This policy establishes the Respiratory Care Bundle for neonates and outlines the associated clinical protocols required for standardized implementation across neonatal intensive care units.

1.4 These recommendations are based upon the MOH scientific committee decision.

1.5 Deviation from this guideline may be required in exceptional circumstances.

2. Abbreviations

CCHD	Critical Congenital Cardiac Disease	iNO	Inhaled Nitric Oxide
CPG	Clinical Practice Guideline	NICU	Neonatal Intensive Care Unit
CV	Conventional Ventilation	NIV	Non invasive
CXR	Chest X Ray	NIPPV	Nasal Intermittent Positive Pressure Ventilation
DR	Delivery Room	PH	Pulmonary hemorrhage
EBM	Evidence-Based Medicine	PPV	Positive Pressure Ventilation
ETT	Endo Tracheal Tube	OR	Operating Room
GIN	Guidelines International Network	RDS	Respiratory Distress Syndrome
HFOV	High frequency oscillation ventilation		

3. Introduction

3.1 All term neonates requiring admission for respiratory support should be managed by this policy.

3.2 All neonates born premature and diagnosed with respiratory distress syndrome RDS and requiring admission for respiratory support should be managed as in policy 5.1

3.3 Any neonate with complication to RDS like pulmonary hemorrhage PH should be managed as in policy and pneumothorax as in policy 5.4

4. Applicability

4.1 This care bundle applies to all Health Care Facilities and staff regulated by the Ministry of Health (MOH).

4.2 All MOH hospital and other health sectors who care for newborn at delivery with different level either in the neonatal intensive care units (NICU) or postnatal ward or well-baby nurseries.

5. Policy Details (Clinical Protocol)

5.1 Respiratory distress syndrome (RDS) In Neonates Management Protocol

5.1.1 Introduction

RDS is caused primarily by deficiency of pulmonary surfactant in an immature lung, leading to significant respiratory insufficiency soon after birth mainly in premature babies. In current clinical practice, the diagnosis of RDS is based on a clinical picture of a preterm infant with the onset of progressive respiratory failure shortly after birth (manifested by an increase in the work of breathing and an increase in the oxygen requirement), in conjunction with a characteristic chest imaging findings (e.g. diffuse reticulogranular ground glass appearance with air bronchograms). The management strategies now prioritize early clinical assessment, focusing on the infant's work of breathing and oxygen requirements, type of respiratory support to guide timely surfactant therapy as in protocol details number 4.3 and prevent disease progression.

5.1.2 Oobjectives:

- To reduce mortality rates, enhance oxygenation, and prevent associated complications like air leak syndrome (pneumothorax).
- To establish a framework for staff education, training, and continuous quality improvement initiatives.

5.1.3 Clinical Presentation

- Onset: Signs typically appear within minutes to hours after birth, especially in preterm infants.
- Respiratory distress signs:
    - Tachypnea (respiratory rate >60 breaths/min).
    - Grunting respirations.
    - Nasal flaring.
    - Chest wall retractions (intercostal, subcostal).
    - Cyanosis or desaturation despite oxygen supplementation.

- Auscultation findings: Reduced air entry with fine inspiratory crackles.
- Progression: Symptoms often worsen over the first 48–72 hours if untreated.

5.1.4 Diagnosis:

- Risk factors:
  - Preterm birth (<34 weeks gestation).
  - Lack of antenatal corticosteroids.
  - Maternal diabetes (increases RDS risk).
  - Delivery by cesarean section without labor.
  - Multiple gestation.
  - Male > female.
- Physical examination: Evidence of respiratory distress (as described above).
- Chest X-ray findings:
  - Diffuse **ground-glass appearance**.
  - Air bronchograms.
  - Small lung volumes.
- Blood gas analysis:
  - Hypoxemia (low PaO_2).
  - Hypercapnia (elevated $PaCO_2$).
  - Respiratory acidosis (low pH).
- Exclusion of other causes: Rule out pneumonia, transient tachypnea of the newborn (TTN), and meconium aspiration.
- Lung ultrasound (optional): "White lung" pattern and absence of A-lines support diagnosis.

5.1.5 Management and Key Recommendations:

5.1.5.1 Prenatal Care

- Transfer mothers at high risk of preterm birth (<28–30 weeks) to tertiary perinatal centers.
- Administer a single course of antenatal corticosteroids before 34 weeks, ideally ≥24 hours before birth.
- Consider a single repeat steroid course if birth does not occur within 7–14 days.
- Use magnesium sulfate (MgSO4) before 32 weeks for neuroprotection (IVH bundle).
- Use progesterone or cervical length screening for high-risk singleton pregnancies.
- Consider short-term tocolysis to complete steroid therapy or transfer.

5.1.5.2. Delivery Room Stabilization

- Delay cord clamping for 30-60 seconds if feasible.
- Use T-piece devices instead of bag-mask ventilation.
- Initiate CPAP (5-7 cm H_2O) for spontaneously breathing preterm infants, if apneic or bradycardic, start giving ventilation breaths Expert consensus is to start with CPAP pressure at least 6 cm H2O and peak inspiratory pressures 20–25 cm H2O
- Begin FiO_2 0.21–0.30 for newborns < 35 weeks and Fio2 0.21 for 35 weeks of gestation and above. Titrate O2 to achieve pre-ductal saturation of >85% by 10 minutes of age.
- Intubation should be reserved for babies not responding to positive pressure ventilation via face mask or nasal prongs (if less than 28 weeks intubation should be attempted by most experience attending physician.
- Use plastic wraps, radiant warmers, and humidified gases for infants <32 weeks to prevent hypothermia.

5.1.5.3. Surfactant Therapy

- Use early rescue surfactant if FiO_2 > 0.40 on CPAP ≥6 cm H_2O.
- Prefer less invasive surfactant administration (LISA) for spontaneously breathing infants.
- Laryngeal mask surfactant may be used for more mature infants >1.0 kg
- Refer to surfactant protocol in policy 4.3.

5.1.5.4. Respiratory Support

- Avoid endotracheal tube ventilation, encourage non-invasive support strategies (NIPPV, nCPAP).
- Start with Non-invasive positive pressure ventilation (NIPPV) or CPAP as first line support.
- NIV with early rescue surfactant by LISA technique is considered optimal management for babies with RDS
- HFNC can be considered as an alternative, with backup CPAP/NIPPV available.
- **If invasive mechanical ventilation cannot be avoided, the use of volume targeted ventilation (VTV) strategies should be strongly considered.**
- Always use blenders when on oxygen therapy.
- Enforce high alarm setting on monitor when infant is receiving oxygen
- Oxygen saturation alarm limits.
- Starting parameters for NIPPV:
  - Respiratory Rate: 30–50 breath/min.
  - Peak Inspiratory Pressure (PIP): 14–21 cm H_2O, in discussion with a consultant may be increased to 24 cm H_2O.
  - Positive End-Expiratory Pressure (PEEP): 6–7 cm H_2O.
  - Inspiratory Time (Ti): 0.45-0.5 sec.
  - FiO_2: Adjusted to maintain SpO_2 per unit guidelines.

5.1.5.5 Mechanical Ventilation (MV) in RDS: Key Principles

Effective management of infants with **RDS** requires a understanding of MV strategies to minimize **iatrogenic lung injury**.
The primary goal is to maintain **adequate blood gas exchange** using the (open lung concept) ventilating at optimal lung volumes while avoiding **over- distension**.

- Use Volume-Targeted Ventilation (VTV):
  - Initial settings: (AC/SIPPV Mode) with Tidal volume (VT) ≈ 4-6 mL/kg; inspiratory times (0.35-0.4 s), Peak Inspiratory Pressure (PIP) ≤ 18–26 cm H_2O (Use Pmax if VG added)
  - adjusted based on work of breathing and blood gas analysis. Typical PEEP range: 5–7, increasing with postnatal age.
  - Babies not on volume targeted ventilation must not be on PTV; they should be on synchronized intermittent mandatory ventilation (SIMV).
- High-Frequency Oscillatory Ventilation (HFOV):
  - Uses tiny tidal volumes at high frequencies with continuous distending pressure (CDP) for optimal lung recruitment.
  - Volume-targeted HFOV reduces CO_2 variability and may offer lung protection.
  - Indication:
  - Starting Parameters: MAP (set 1-2 cm H2O above the P mean in conventional ventilation.
  - Amplitude (double MAP) guided to achieve visible wiggling down to umbilicus.
  - Premature infants: 11-13 Hz. (Usually start 12), higher frequencies used for more preterm infants or those with sever RDS or pulmonary interstitial emphysema (PIE).
  - Term infants: 8-12 Hz. (Usually start 10)
  - FiO_2: Adjusted to maintain SpO_2 per unit guidelines.

5.1.5.6 Blood gas monitoring

- Must occur on all neonates receiving respiratory support
- Ventilated neonates must have a gas at least Six hourly initially.
- More frequent monitoring must occur in unstable neonates.
- A CO2 below 30 mmHg must be acted upon within 10 minutes and the gas repeated within 60 minutes.
- Significant changes in ETCO2 should prompt a repeat blood gas. **(Refer to ETCO2 guidelines)**
- Target PCO2 in preterm babies in the first 72 hours of life between 45- 60.

5.1.5.7 Inhaled Nitric Oxide (INO):

- Proven therapy for hypoxemic respiratory failure in term infants with pulmonary hypertension.
- Not beneficial for mortality or BPD reduction in preterm infants <34 weeks but may be considered in severe hypoxic respiratory failure with documented pulmonary hypertension.
- * Referred to iNO Protocol.

5.1.5.8 Weaning and Extubating:

- Initiate weaning to non-invasive ventilation (NIV) as soon as spontaneous breathing is adequate.
- Unfortunately, the ability to determine the extubation criteria has proven to be very difficult. In the absence of specific protocols, weaning from MV, the rates of weaning ventilatory parameters and the decision to extubate is still based on clinical evaluation, blood gases, oxygen needs and level of ventilatory support.
- In the absence of objective, evidence-based criteria, there is still no consensus on the ventilator settings at which a preterm infant should be considered for extubation with a high likelihood of success.

* Patient are weaned from sedation and sufficiently awake.
* The Neonate is hemodynamically stable (inotropes are not absolute contraindications) and vital signs are within acceptable parameters.
* Patient is demonstrating good spontaneous respiratory effort, with minimal ventilatory settings:

- conventional ventilation (Fio2 Less than or equal 40%, TV Less than 5ml/kg)
- HFOV (Fio2 Less than or equal 40%, MAP less than or equal 13 for term and 12 in extreme preterm, Amplitude is almost double the MAP).
- baby has manageable secretions.
- Extubation to higher CPAP (7–9 cm H_2O) or NIPPV improves success and reduce risk of re-intubation.

5.1.5.9. Oxygen and Monitoring

- Target oxygen saturation (SpO_2) between 90–94% with alarm limits 88–95%.
- Regularly monitor blood gases, cardiovascular stability, and signs of hypoxia/hyperoxia.

5.1.5.10 Caffeine Therapy

The Caffeine for Apnea of Prematurity (CAP) study confirmed that caffeine citrate in the standard dose of 20 mg/kg loading with 5–10 mg/kg day maintenance for infants < 1251 g or less than 32 weeks GA coming off MV, or being treated for apnea, resulted in less need for respiratory support subsequently less BPD, and long-term follow-up also showing improved neurodevelopmental outcomes.

5.1.5.11 Postnatal Steroids

- The lower dose dexamethasone regimen described in the DART trial seems to get the best balance of clinical effectiveness with minimizing risk of longer-term side effects. Low-dose prophylactic hydrocortisone for 10–15 days from birth also improves chances of survival without BPD and reduces need for PDA treatment

5.1.5.12 Supportive Care

- Maintain normothermia (36.5–37.5°C).
- Start parenteral nutrition at birth and initiate early enteral feeding with mother's milk as soon as baby can fed.
- Use antibiotics judiciously and discontinue if sepsis is excluded (you can use MOH guidelines).
- Monitor blood pressure and use inotropes as necessary.

5.2 Pulmonary Hemorrhage (PH) In Neonates Management Protocol

5.2.1. Introduction

Pulmonary hemorrhage (PH) is generally described as an acute event characterized by the sudden discharge of bloody fluid from the upper respiratory tract or through the endotracheal tube [1].

Pulmonary hemorrhage (PH) in neonates is a severe and often life-threatening event primarily affecting premature infants, particularly those with very low birth weight (VLBW) [2] and intrauterine growth restriction (FGR) or those who are small for gestational age (SGA) [3]. It mainly occurs during the first 48 to 96 h of life, i.e., during the transitional period [4]. PH is characterized by rapid clinical deterioration, often leading to acute hypoxemia and respiratory failure. Its occurrence is strongly associated with several neonatal complications, including birth asphyxia and hypothermia [5], respiratory distress syndrome (RDS) [6–8], sepsis [9,10], and patent ductus arteriosus (PDA) [8,10]

5.2.2. Objectives

- To establish a standardized evidence-based approach for the diagnosis, stabilization, and management of pulmonary hemorrhage.
- To minimize mortality, optimize oxygenation, and prevent recurrence.
- To provide a framework for staff training and quality improvement.

5.2.3. Risk Factors

- Extreme prematurity (<28 weeks' gestation).
- Severe RDS requiring mechanical ventilation (A sudden drop in PVR after surfactant therapy and pressure from the mechanical ventilator leads to capillary trauma)
- Hemodynamically significant PDA and pulmonary over circulation—Pulmonary edema and capillary rupture.
- Stress failure of pulmonary capillaries—The disruption of the endothelial barrier, allowing hemorrhagic fluid to leak into alveoli.
- Left ventricular stiffness and diastolic properties—Myocardial workload and afterload mismatch.
- Fetal growth restriction—Coagulopathy, thrombocytopenia, platelet dysfunction, and cardiovascular dysfunction.
- Sepsis or severe infections (Profound microvascular injury and inflammation)
- Possible factors—congenital heart disease, asphyxia, hypothermia, and lower coagulation factors in neonatal populations.
- Genetic factors—HHT (hereditary hemorrhagic telangiectasia) : impaired vascular integrity; hemophilia: bleeding disorder
- High ventilatory pressures or aggressive fluid management.

5.2.4-Protective Factors:

- Antenatal glucocorticoids—Enhancing surfactant production and stabilizing the pulmonary vasculature.
- Prophylactic indomethacin—Lower incidence of early, severe PH (within the first week of life mainly <26 weeks).

5.2.5. Clinical Presentation

- Acute onset of bloody endotracheal aspirates or blood-stained secretions.
- Sudden desaturation, bradycardia, apnea, pallor, and hypotension.
- Decreased tidal volumes and increased ventilator pressures.
- Chest X-ray: Diffuse alveolar infiltrates ("white-out" appearance) or localized opacities.
- Lung ultrasound (LUS) has emerged as a valuable, non-invasive diagnostic tool for PH. LUS can detect increased pulmonary echogenicity, consolidations, and alveolar–interstitial syndrome, aiding in the early identification of PH in the clinical context

5.2.6 Initial Stabilization (First-Line Management)

1- Airway and Oxygenation

- Ensure a patent airway: Endotracheal intubation if not already in place.
- Suctioning of blood from the airway to improve ventilation.
- 100% oxygen initially to achieve target SpO_2 (90–95% for preterm, 92–97% for term neonates).
- High-frequency oscillatory ventilation (HFOV) may be considered early for severe cases.

2- Circulatory Support

- Volume resuscitation with isotonic fluids (10 mL/kg normal saline), if hypotensive.
- Inotropes (dopamine or dobutamine) for persistent hypotension.
- Correct metabolic acidosis

3- Coagulopathy Management

- Check CBC, PT, aPTT, fibrinogen.
- Administer fresh frozen plasma (FFP) (10–15 mL/kg) if coagulopathy is present.
- Platelet transfusion if platelet count <100,000/µL.

5.2.7 Specific Interventions:

5.2.7.1 Surfactant Therapy

- Repeat or rescue surfactant therapy is indicated for neonates with RDS and PH, as surfactant is often inactivated by blood.
- Evidence: Studies show improved oxygenation and outcomes with surfactant replacement

5.2.7.2 Patent Ductus Arteriosus (PDA)

- The echocardiographic is essential to assess pulmonary artery pressure (PAP), right ventricular (RV) function, and systemic blood flow (SBF) [74]. Key parameters include estimates of pulmonary artery pressure (PAP), RV function, and systemic blood flow (SBF).
- Treat significant PDA with Paracetamol or ibuprofen, as PDA closure reduces pulmonary over circulation and risk of recurrent PH.

5.2.7.3 Ventilation Strategies

- Avoid aggressive suctioning or high airway pressures.
- Use PEEP (positive end-expiratory pressure) cautiously to tamponade bleeding while maintaining oxygenation.
- HFOV or high-frequency jet ventilation (HFJV) may be beneficial if available.

5.2.7.4. Endotracheal Epinephrine

- Although not standard therapy, endotracheal epinephrine may be considered in life- threatening cases of PH, particularly during resuscitation or when bleeding is refractory. Epinephrine administered via the endotracheal tube (ETT) induces localized pulmonary vasoconstriction to help control the hemorrhage. While effective, this approach carries potential risks, including airway or vocal cord ischemia, local tissue necrosis, arrhythmias, systemic vasoconstriction, hyperglycemia, lactic acidosis, and hypertension.

5.2.8 Pharmacologic Adjuncts

- Recombinant activated factor VIIa (off-label): For refractory cases, limited evidence but described in severe PH.
- Vitamin K (1 mg IV/IM) if deficiency is suspected.
- Antibiotics: If infection or sepsis is suspected, start empirically after blood cultures.

5.2.9 Monitoring and Support

- Continuous cardiorespiratory and pulse oximetry monitoring.
- Serial blood gases and hematocrit (HCT) (may require packed RBC transfusion if HCT <35–40%).
- Frequent chest X-rays to assess lung status and progression.

5.2.10 Prevention Strategies

- Antenatal corticosteroids for mothers at risk of preterm delivery (reduces incidence of RDS and PH).
- Optimal surfactant use and gentle ventilation to reduce barotrauma.
- Early PDA screening and closure in high-risk preterm infants.

5.3 Surfactant Administration Protocol

5.3.1 Introduction:

The intratracheal administration of exogenous surfactant has been shown to reduce the severity of respiratory distress and decrease mortality among infants. Surfactant therapy is now considered a standard practice for both the treatment and prevention of hyaline membrane disease (HMD) in neonates.
Surfactant administration must be performed by privileged medical staff or by privileged neonatal respiratory therapist under the direct supervision of senior medical staff.

5.3.2 Indications

1. Rescue Therapy

- Surfactant can be administered after delivery and up to 6–12 hours of age (Avoid DR or OR administration preferably in NICU) with confirmed RDS characterized by:
- Mechanical ventilation requirements.
  FiO_2 > 0.4 and MAP > 7 cm H_2O (not weanable).
- Respiratory acidosis with Pco2>60.
- Inappropriate work breathing with non-invasive ventilation support.

- **Additional indications to be considered:**
  - Meconium aspiration syndrome.
  - Pulmonary hemorrhage.
  - Selected cases of pneumonia, pulmonary hypoplasia, and congenital diaphragmatic hernia (evidence for benefit remains limited).

5.3.3 Types of available Surfactant

- Survanta (Bovine): 4 mL/kg (100 mg phospholipids/kg), every 6 hours, up to 4 doses.
- Infasurf (Bovine): 3 mL/kg (105 mg phospholipids/kg), every 12 hours, up to 3 doses.
- Exosurf (Synthetic): 5 mL/kg (67.5 mg/kg Colfosceril Palmitate), every 12–24 hours, up to 3 doses.
- Bless (Bovine): 5ml/kg (135mg phospholipids/kg), every 8-12 hours, up to 3 doses.

5.3.4 Required Equipment

- Surfactant warmed to room temperature.
- 10 mL syringe.
- 20 G needle.
- Sterile 5 Fr feeding tube (for Survanta).
- Sterile blade (for Survanta).
- Sterile gloves.
- Ambu bag / ventilator.
- Cardiac monitor.
- Laryngoscope with blade (size according to gestational age of the baby)
- Endotracheal tube (size according to the gestational age of the baby)
- Adhesive tape for fixing the ETT

Administration Procedure

- Verify the order for surfactant in the physician's orders. (Dose given will be determined by what product is used).
- Warm the surfactant to room temperature.
- Verify the newborn's identification.
- Perform hand hygiene according to protocol and don sterile gloves.
- Draw Surfactant into the syringe, being careful not to shake.
- Attach the sterile feeding tube to the syringe and fill the catheter.
- Position the newborn supine and ensure leads are connected to the bedside cardiopulmonary monitor.
- Disconnect the newborn from the ventilator if intubated.
- Insert the feeding tube into the endotracheal tube just above the end of the endotracheal tube above the level of carina.
- Follow the manufacturer's recommendations for administering the surfactant.
- Observe the newborn very carefully and pay close attention to chest expansion, changes in tidal volume, need for increase/decrease in supplemental oxygen and alterations in vital signs, including pulse oximetry.
- Between doses of surfactant the newborn may be hand ventilated or placed on the ventilator to allow the neonatal vital signs to return to baseline. Closely observe for changes in respiratory function.
- If the newborn becomes hypoxic or bradycardic during surfactant administration, dosing should be stopped until the newborn is stable.
- After administration is complete, re-connect neonate to mechanical ventilator, monitor vital signs and respiratory status very closely. Some newborns will require rapid changes in ventilatory parameters.
- Obtain arterial/capillary blood gases as ordered to evaluate acid-base, ventilation, and oxygenation.
- Do not suction the neonate for at least one (1) hour post-dosing unless there is a clinical emergency that warrants suctioning.

5.3.5 Precautions

Before dosing:

- Confirm correct ETT placement via auscultation and chest expansion (preferable CXR).
- Check centimeter markings at the gum (6 + weight in kg).
- Suction ETT if required.

During dosing:

- Monitor chest expansion (reduced movement may indicate airway obstruction).
- If obstruction occurs, temporarily pause dosing or increase PIP.
- Continuously monitor oxygenation; address hypoxemia promptly.

After dosing:

- Rapid changes in lung compliance may require frequent adjustment of PIP, FiO_2, PEEP, and rate.
- Wean settings quickly to avoid pneumothorax or pulmonary interstitial emphysema.

Adverse Effects:

- Pulmonary hemorrhage.
- Transient bradycardia, hypotension, oxygen desaturation, and the potential for endotracheal tube blockage.
- Pneumothorax.

5.4 Neonatal Lung Pneumothorax Protocol

5.4.1. Introduction

A pneumothorax is an air leak that develops between the visceral and parietal pleura following the rupture of an over distended alveolus. The incidence is 1- 2% of live births. The incidence is higher in preterm infants who often have underlying respiratory distress syndrome. Other risk factors for pneumothorax include meconium aspiration syndrome, severe lung disease, pulmonary hypoplasia, delivery room intubation, surfactant administration and any form of respiratory support (invasive and non-invasive). Pneumothoraces also develop spontaneously.

5.4.2. Clinical Presentation & Diagnosis

Pneumothorax should be suspected in neonates with sudden respiratory deterioration, hypoxia, increased oxygen requirements, diminished breath sounds, or asymmetrical chest movements. Confirm diagnosis via chest X-ray or bedside lung ultrasound. In suspected tension Pneumothorax, emergency intervention should not be delayed for imaging.

5.4.3. Management Overview

5.4.3.1 Expectant (Conservative) Management

Observation is suitable for asymptomatic or mild Pneumothorax without significant distress. Ventilated neonates with small leaks may also be managed conservatively if stable.

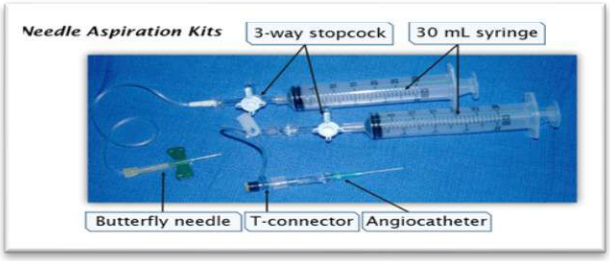
5.4.3.2 Emergency Needle Aspiration (Thoracentesis)

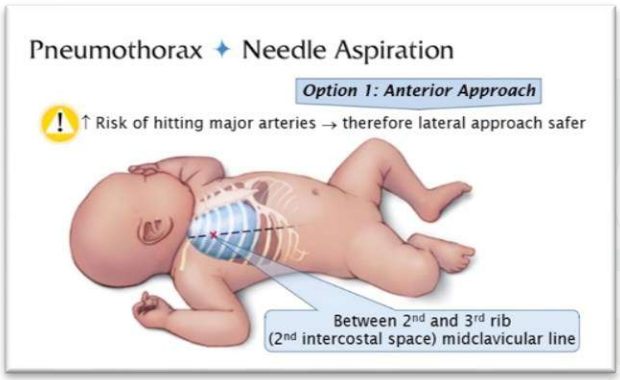
Indicated in cases of tension Pneumothorax or severe respiratory compromise.

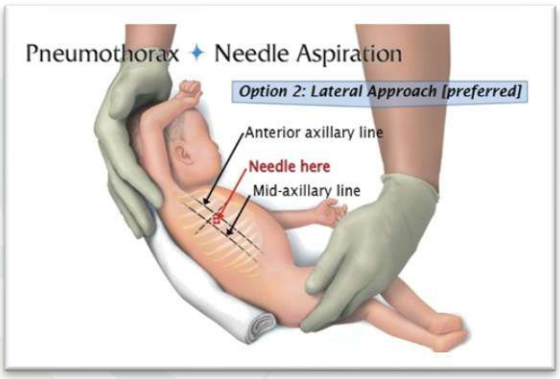
- Needle aspiration equipment:
  - 18- or 20-gauge angiocatheter (preferred) or 21or 23-gauge butterfly needle.
  - 20 or 30 ml syringe.
  - 3-way stopcock.
  - T-connector or short IV tubing (if using angiocatheter).
  - Antiseptic solution to clean skin.

-Needle aspiration site:

- Between 2nd and 3rd intercostal space midclavicular line.
- Between 4th and 5th intercostal space in the mid-axillary line.

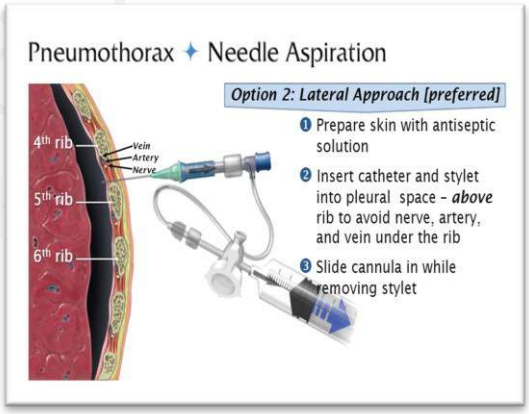






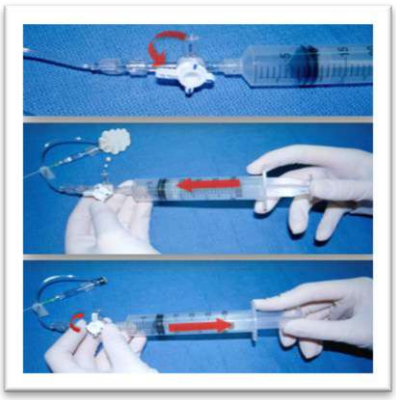
- Needle aspiration Procedure:

- Prepare skin with antiseptic solution.
- Insert catheter and stylet into pleural
- space-above rib to avoid nerve, artery, and vein under the rib.
- Slide cannula in while removing stylet.
- Attach T-connector / stopcock /syringe.
- Open stopcock to patient.
- Aspirate on plunger until resistance is met or
- syringe is full of air.
- Turn stopcock off to patient.
- Push air out of syringe.
- Repeat process until all air is evacuated.



5.4.3.3 Intercostal Catheter (ICC) / Chest Tube insertion:

Required when needle aspiration fails or in recurrent or large leaks.
Pigtail catheters (8–10 Fr) connected to underwater seal or Heimlich valves are preferred.

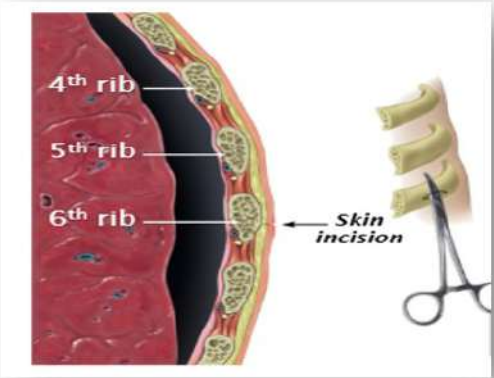


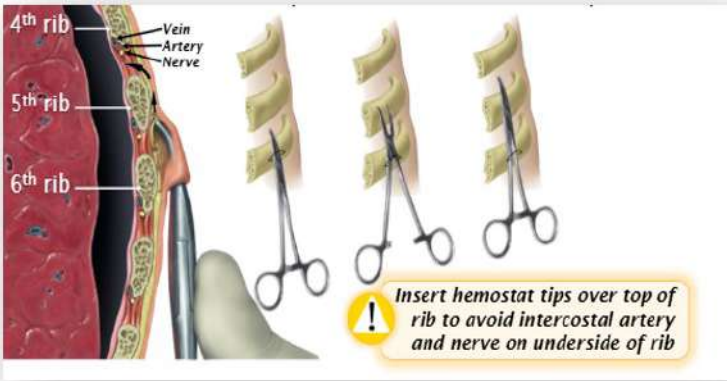
5.4.4. Equipment Checklist

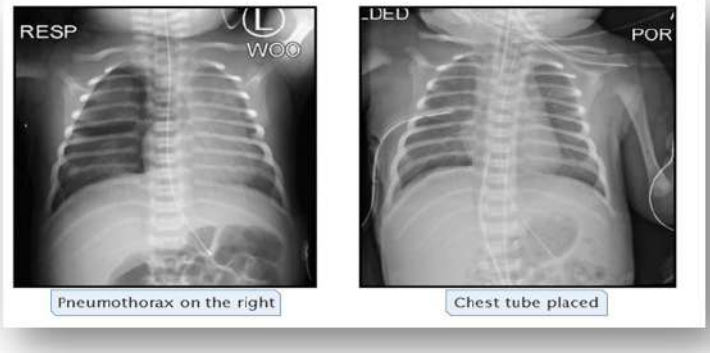
- Butterfly needle (23–25G) and syringe
- Stopcock and drainage tubing
- Pigtail catheter set (appropriate size)
- 1% lignocaine, sterile gloves, and drapes
- Antiseptic solution and sterile gown
- Ultrasound or X-ray access

5.4.3 procedure:

- Administer analgesia prior to the procedure if possible. If emergent procedure, administer analgesia as soon as possible during the procedure.
- Gently position the newborn at 45 angle with pneumothorax side up.
- Set up the closed underwater drainage system according to the manufacturer's instructions and ask physician for the amount of negative pressure to be used (normal range: 10– 15 cm H2O).
- prepare skin with antiseptic solution and drape the area for chest tube insertion.
- Make a 1 cm incision through the skin and subcutaneous tissue using a small (number 11) scalpel blade.
- Bluntly dissect away the subcutaneous tissue and intercostal muscles using straight mosquito forceps over 5th rib to 4th intercostal space to reach the parietal pleura.
- Remove the trocar from the ICC and advance the ICC into the pleural space 2-5 cm (ensure all side holes are within pleural space), directing the tip anteriorly as well as super medially, so that the tip lies anteriorly inside the chest cavity.
- the chest tube should be connected to the evacuation device immediately at the ordered pressure (10-20 cm H2o)
- Secure tube with suture and steri-strips.
- Call for x-ray to confirm placement of the tube.
- Apply Vaseline gauze around chest tube at the insertion site and then apply the transparent semipermeable dressing.
- Tape all connections securely. Secure the tubing to the mattress with tape and safety pin.







5.4.4 Post-Drainage Care & Monitoring

- Perform clinical reassessment, vital signs monitoring and repeat imaging post procedure and 24 hours after intervention or prior if indicated.
- Observe for oscillation of fluid in the chest tube to ensure communication between the pleural space and the evacuation system.
- Observe for fluctuation in the water seal chamber.
- The vacuum should be set so there is gentle bubbling in the suction chamber. At least once per shift, kink the tubing to the vacuum to stop the vacuum and note how much water is in the chamber. Refill to the ordered pressure.
- Stabilize the chest tube by holding it close to the chest when repositioning the baby or moving for procedures such as x-rays.
- Note that the drainage tubing is secured to the bed and no tension is placed on the chest tube.
- Presence of clots or debris may require gentle kneading of the tube. DO NOT milk or strip tubes as the excessive pressures generated could damage the lung.
- Maintain the evacuation system at a place where it will not be kicked or knocked over. The system must always be below the level of the newborn's chest to prevent water from being pulled into the pleural space.
- Monitor character, consistency and amount of drainage.
- A rubber-tipped hemostat should always be kept at the bedside in case of accidental disconnection.
- Clamp ICC for 6-12hours before removal if stable.
- Monitor for complications such as infection, persistent air leak, or malposition.

5.4.5. Post-Drainage Care & Monitoring

- Perform clinical reassessment and repeat imaging 24 hours after intervention. Clamp ICC for 24 hours before removal if stable. Monitor for complications such as infection, persistent air leak, or malposition.

5.4.6. Preventive Strategies

- Use lung-protective ventilation strategies (volume-targeted or high-frequency modes). Carefully titrate CPAP pressures and use early surfactant therapy as indicated to reduce air-leak risk.

5.4.7. Outcomes & Prognosis

- Pneumothorax is associated with increased risks of bronchopulmonary dysplasia (BPD), intraventricular hemorrhage (IVH), and mortality, particularly among extremely preterm infants (<26 weeks). Prompt recognition and management are essential to improve outcomes.

5.5 Nitric Oxide Usage Protocol in Neonates

5.5.1 Introduction

Nitric oxide (NO) is a potent vasodilator used to treat pulmonary hypertension. It is a gas that is given into the ventilator circuit and is inactivated instantly in blood, by reacting with hemoglobin. Therefore, it produces rapid and localized effects on the pulmonary vasculature with presumed minimal action on the systemic vasculature or systemic blood pressure.

5.5.2 Purpose

This guideline describes the process to administer inhaled nitric oxide (iNO) via high frequency, conventional ventilator.

5.5.3 eligible group

- Neonates with symptomatic Persistent Pulmonary Hypertension of the Newborn (PPHN) – proven clinically (i.e. 10% differential in pre/ postductal saturations), or by point of care ultrasound/echocardiography
- Neonates with severe hypoxemic respiratory failure (i.e. oxygenation index>20, PaO2 <60 mmHg or <8kPa despite 100% FiO2), caused by e.g. hypoxic ischemic encephalopathy, meconium aspiration/exposure, postoperative pulmonary hypertension.
- Used with caution in preterm infants < 34 weeks GA, as rescue treatment for severe hypoxic respiratory failure on a case-by-case basis.

5.5.4 Clinical Management

5.5.4.1 Equipment

iNO delivery circuit set up guideline is available at:

- Assemble equipment according to iNO delivery circuit set up guideline
- Spare equipment for setup of NO delivery circuit can be found in RT NICU workroom

Oxygenation Index (OI)

$$OI = \frac{\text{Mean Airway Pressure} \times FiO_2 \times 100}{PaO_2}$$

SSH OI calculator: see

https://www.starship.org.nz/health-professionals/calculators/respiratory-indices-calculator/

Cautions:

- Preferably to do Echocardiogram to exclude cyanotic (duct dependent) congenital heart disease before use iNO
- Gestation >34 weeks. (In exceptional circumstances inhaled nitric oxide may be used in preterm infants <34 weeks as a rescue remedy but requires discussion with consultant)
- Absence of lethal congenital malformation
- Careful consideration in presence of IVH (grade 2-4) or coagulopathy
- Use in-line suction catheter to avoid interruption of circuit.
- Optimize lung inflation: Efficacy of iNO is dependent on the degree of lung inflation (i.e. less effective if lung under-expanded).
- Do not turn off ventilator during procedures such as reintubation or hand bagging.

5.5.4.2 Initiating treatment with inhaled Nitric oxide (iNO)

- Before starting iNO: document clinical parameters to categorize iNO response
- Start iNO at 20ppm: do NOT change other parameters or touch the baby

5.5.5 Monitoring

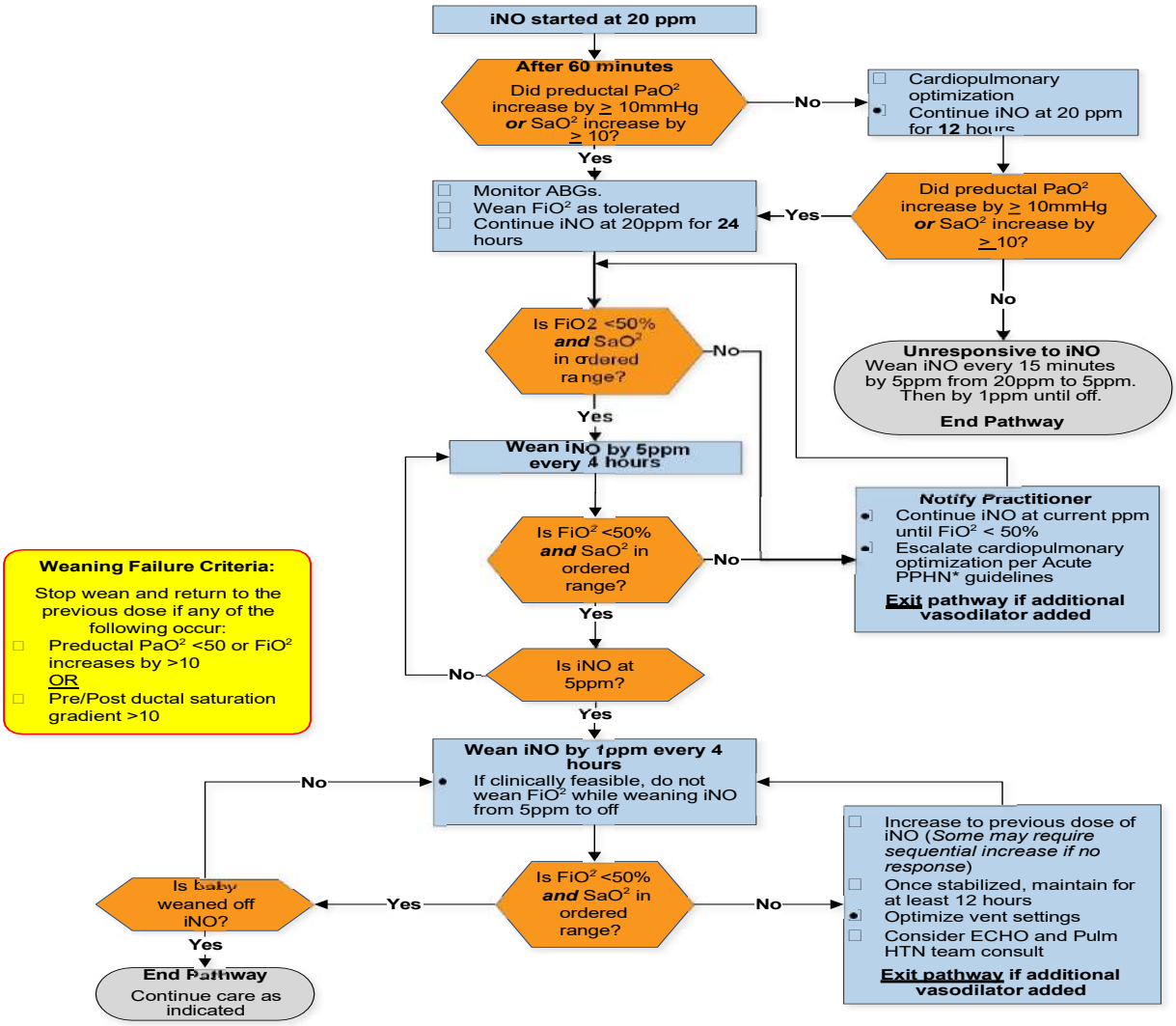
- Continuous monitoring of heart rate, blood pressure and (arterial) oxygen saturation (refer Oxygen Therapy for Newborns in NICU protocol) with hourly documentation
- OI calculation (see above) on arterial blood gases
- Pre and post ductal saturation monitoring
- Measure Methemoglobin (from blood gas) after 1 hour and 12 hours (approximately) following commencement of iNO therapy to exclude methemoglobin reductase deficiency. If methemoglobin >5%, need to stop NO, inform SMO, and consider rescue therapy with methylene blue.
- Monitor Nitrogen Dioxide (NO_2) levels in inspiratory gases (upper limit 5ppm).

5.5.6 Weaning

Exogenous iNO suppresses production of endogenous NO, therefore slow weaning, especially for the last few ppm is advised in order to avoid rebound PPHN. See the pathway.

Inhaled Nitric Oxide Weaning

Neonatal Intensive Care Unit



5.5.7 Potential Complications

- Platelet dysfunction and bleeding
- Methemoglobinemia (upper limit 5%)
- Nitrogen Dioxide (NO2) poisoning – pulmonary oedema, ARDS
- Reduced FiO2 in inspiratory gases due to displacement by NO (probably negligible)
- Prevents pulmonary vascular bed remodeling (prolonged use in animal experiments)

NOTE: There are no restrictions for pregnant staff members to care for babies treated with iNO.

5.6 Transcutaneous CO2 monitoring in NICU Protocol

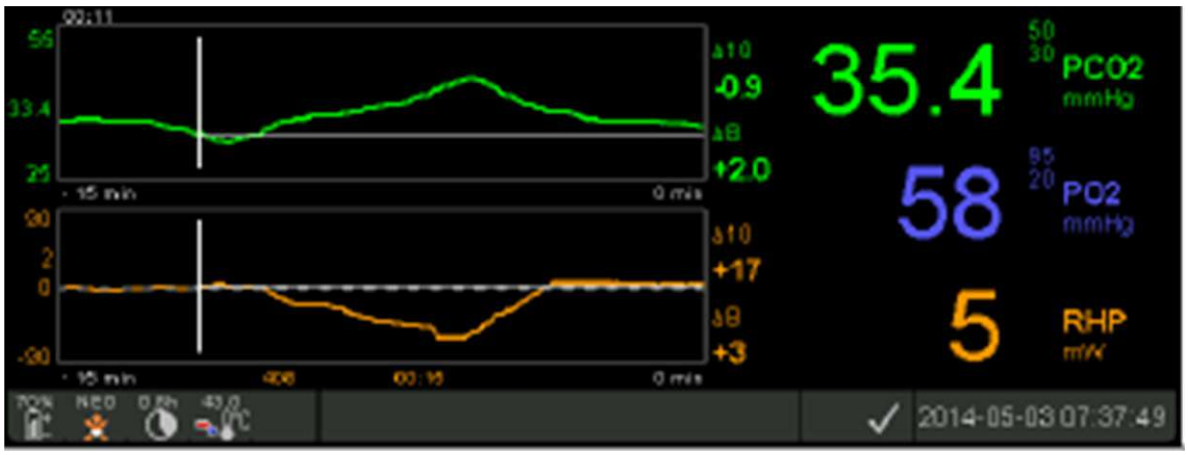
5.6.1 Introduction

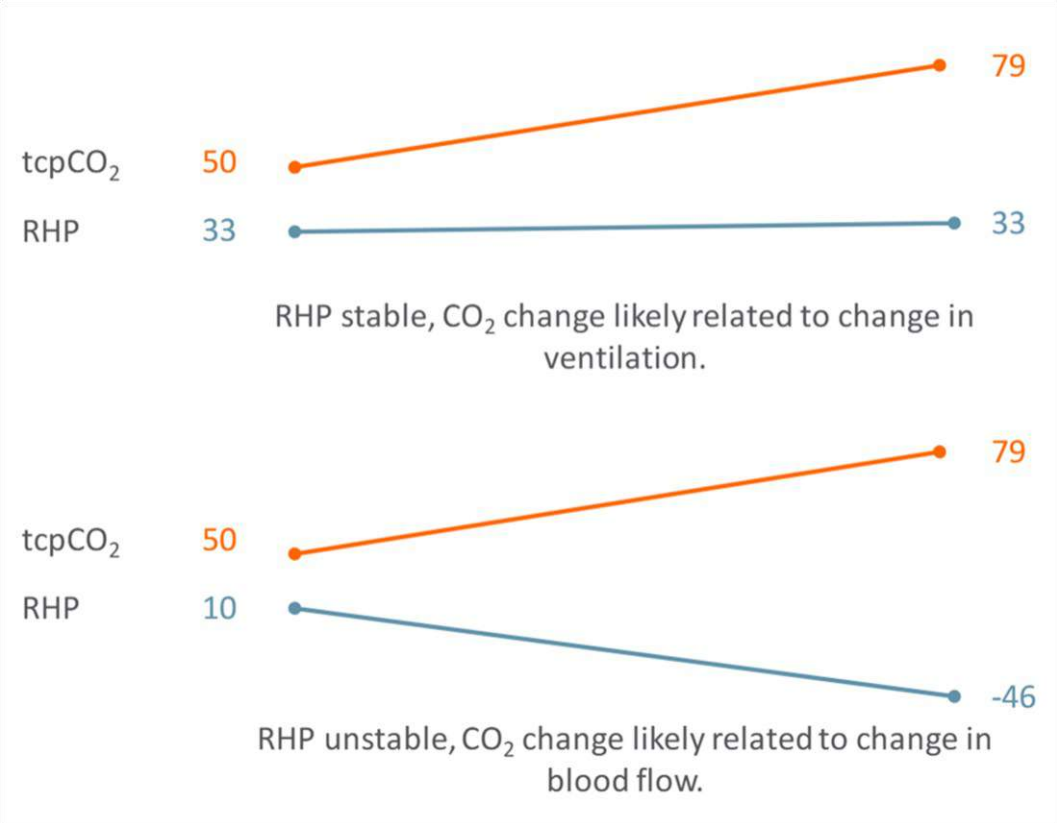
This protocol aims to guide the reader in the use of transcutaneous CO2 monitoring in preterm and term babies admitted to the neonatal unit.

5.6.2 Purpose

Using transcutaneous measurements has the potential to reduce the number of blood gases needed to manage ventilation, result in more stable oxygen and carbon dioxide status and alert medical and nursing staff to a change in the condition of the baby. The transcutaneous sensor gently warms the skin underneath the sensor to increase the blood flow _ which enables monitoring of transcutaneous CO_2 ($tcPCO_2$) and O_2 ($tcPO_2$).

Heating power relates to the power required to maintain the sensor at the set temperature. AHP (Absolute Heating Power) is the total power needed to heat the connected sensor to the selected "Sensor Temperature" whenever the sensor is outside the Docking Station. RHP (Relative Heating Power) shows deviations of the current heating power from a stored RHP-reference value. RHP is set automatically by the monitor once the sensor stabilizes on the skin. RHP can also be set by the user manually at any time (for example when the $tcPCO_2$ value correlates well with an ABG). A well perfused baby requires a higher AHP than a poorly perfused baby to keep the sensor temperature stable and leads to a more accurate estimate of arterial PCO_2. Heating power can help to identify whether a change in tcPCO2 displayed has occurred because of a change in blood flow vs change in the respiratory status.





5.6.3 Eligible patients

Babies with significant respiratory illness (i.e. FiO_2> 60%, PCO_2> 60 mmhg (arterial or capillary), escalated to HFOV, underlying pathology of PPHN, MAS, CDH, or babies needing a reduction in the number of blood samples can be started on transcutaneous monitoring after discussion with attending consultant.

5.6.4 Relative contraindications

- Fragile skin (such as epidermolysis bullosa) – Consider the placement of the Non-Adhesive Wrap on the patient's thigh.
- Body cooling, poor perfusion (due to sepsis, cardiac condition, or edema), or inotropic support as these may lead to falsely high $tcPCO_2$ and falsely low $tcPO_2$- Consider using the tcPCO2 value as a trending tool to monitor for acute changes in patient's ventilatory status that can have negative effects on cerebral blood flow.

5.6.5. Clinical Management

Transcutaneous CO2 monitoring is an important non-invasive tool for the management of babies on both invasive and non-invasive ventilation. This is additionally useful for babies with respiratory distress and poor respiratory drive even when not supported with any respiratory support.

Indications for use of TCO2 monitoring:

- In all intubated babies
- Post extubation for a minimum of 24 hours with stable FiO2 <30%
- Premature babies requiring non-invasive respiratory support e.g. BIPAP/CPAP/HFNC. If on HFNC - consider stopping when stable for at least 24 hrs with a maximum VT of 5 LPM and stable FiO2 <30%
- In all babies following surfactant administration (through LISA procedure or other modes) for a minimum of 24 hrs
- Any other baby with reduced respiratory drive or increased respiratory distress – If in doubt – please discuss with Registrar /Consultant

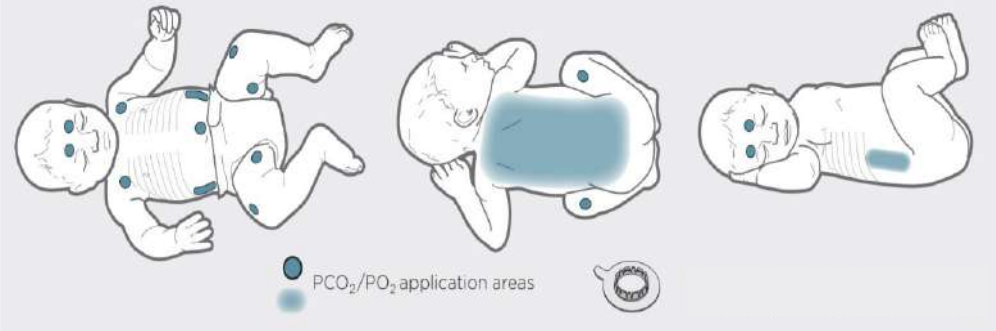
5.6.6 Equipment

- Machine providing TCO2 like Sentec should never be switched off and needs to display "ready for use"
- Take sensor out of docking station and check integrity of sensor membrane before use
- Select NICU mode and check alarm limits
- Alarm limits
- Temperature set at 40-41 °C
- Site time set at 2 hours
- $tcPCO_2$ accepted between 4.7-6 kPa and $tcPO_2$ accepted between 4-10 kPa
- Alarm limits may be changed after discussion with MRP in selected babies. This needs to be documented in medical and nursing notes.
- Have attachment rings (MAR or SF-MAR) and Sentec contact gel ready

5.6.7 Patient preparation

- Choose relevant attachment ring
  - MAR: standard ring, which will "stick" better
  - SF-MAR: individually packaged for more sensitive or fragile skin
- Choose 2 (or 3) sites to place the attachment ring on (see below diagram)
- Clean the skin with alcohol or unit recommendation for cleaning skin of a neonate and allow to dry well prior to placing attachment ring.

5.6.8 Sensor application



Please note: The forehead is not used as sensor application site in our NICU due to the risk of scarring from a burn

- Apply ONE drop of Sentec contact gel to the skin in the centre of the ring.
- Hold sensor by cable. Insert nose of sensor at an angle (as shown) then apply light downward pressure with forefinger to snap it into place. (Think of 'landing' it like an airplane)
- Twist the sensor in the ring (full 360° if possible) to spread contact gel evenly.
- After sensor application, $tcPCO_2$ readings typically stabilize within 2 to 10 minutes. After stabilisation, the displayed value turns from **grey** to **green**.

5.6.9 Limitations of TCO2 monitoring:

Babies on TCO2 monitoring will need to have the values correlated with blood gas CO2 at regular intervals to have an understanding of the trends of TCO2 levels for any particular baby.

5.7 Intubation Protocol in Neonate

5.7.1 Purpose

The purpose of this policy to provide rational and protocol for neonatal tracheal intubation.

5.7.2 Indication:

Neonatal tracheal intubation is required for a number of reasons including airway management emergency or electively like for procedure like ROP transport, radiological study e.g. MRI procedure, elective surgeries, surfactant administration and assisting ventilation in respiratory insufficiency.

Assessment: of the infant and decision to proceed with intubation, a structured and safe approach should be taken, as covered in this policy. The procedure has the potential to provoke marked physiological changes and should never be undertaken lightly[1,2]. In addition to potential cardio-respiratory instability, there are significant complications that may arise from trauma to the tissues, including potential to cause perforation of the pharynx, esophagus or trachea.

5.7.3. Staffing:

- Intubation requires staff who are skilled in the management of the infant airway, generally an experienced middle grade doctor, suitably experienced NRP, privileged for intubation and/or a consultant.
- Intubations should always be performed with senior supervision.
- Intubation should be attempted by the most experienced member of the team in emergency or lifesaving procedure.
- LIMIT THE NUMBER OF ATTEMPTS TO 2 TRIAL PER PERSON especially in the elective intubation like for procedures or transport.
- Elective intubation should be planned and decided by consultant (on service or on call)
- Special consideration and escalation planning should be undertaken taken if there has been a previous difficult intubation, or if there is a suspected airway abnormality or congenital anomaly of the head or neck. Please refer to the difficult airway policy.

5.7.4 Pre-Medication for elective intubation:

Intubation is a painful & uncomfortable procedure[1,3]. Suggestive premedication makes the procedure easier, safer and better tolerated by the baby. It provides analgesia and facilitates smoother passage of the ET tube by allowing jaw relaxation, opening and immobilising the vocal cords, and by preventing coughing, gagging or diaphragmatic movements[3].

- A combination of a sedative and muscle relaxant has been shown to shorten time to successful intubation and lessen the physiological unwanted effects. Intubation without drugs is associated with hypoxia, vagal bradycardia and hypertension, with secondary effects on intracerebral perfusion.
- Premedication can be used for the majority of elective and emergency intubations on the neonatal unit. Caution should be used if there are concerns about airway obstruction and there should first be a discussion with the consultant.
- Tracheal intubation without the use of premedication should only be considered in the delivery room or emergency life-threatening situations where IV access is not available[3].

5.7.4.1 Medication:

- While the evidence regarding the best combination of sedative and muscle relaxant is lacking, the regime detailed in this document has the most evidence in the preterm and newborn population[2,7-9].

- Routine practice in the NICU involves the use of fentanyl and suxamethonium. Fentanyl is the recommended analgesic for intubations. Midazolam or Morphine should only be used if no other alternative. Suxamethonium is the preferred paralytic agent due to its rapid onset and short duration of action. Atropine is an antimuscarinic agent that helps to prevent reflex bradycardia and instability as a result of exaggerated vagal response during laryngoscopy. Consideration should be given to using atropine routinely as part of pre-medication in order to promote cardiovascular stability.

All staff giving premedication must be familiar with the correct administration procedures and the team leader must ensure this prior to starting.

	Dose	Pre-Made Syringe Dose (if available)
Fentanyl	0.5-3 mcg/kg/dose (slow IV push) 5-10 minutes	
SUXAMETHONIUM	2 mg/kg/dose IV	
Atropine	0.02 mg/kg IV (2 minutes prior intubation)	

5.7.4.2 ADMINISTRATION OF PRE-MEDICATION:

Fentanyl		
0.5-3 mcg/kg/dose OR	Push over 5-10 minutes IV slowly 0.5-1ml flush over 30-60 seconds	Followed by

↓

Atropine		
0.02 mg/kg/dose OR	IV 2 minutes prior intubation 0.5-1ml flush over 30-60 seconds	Followed by

↓

SUXAMETHONIUM		
2 mg/kg/dose IV OR	Bolus 10-20 seconds 0.5-1ml flush over 30-60 seconds	Followed by

5.7.5 Procedure:

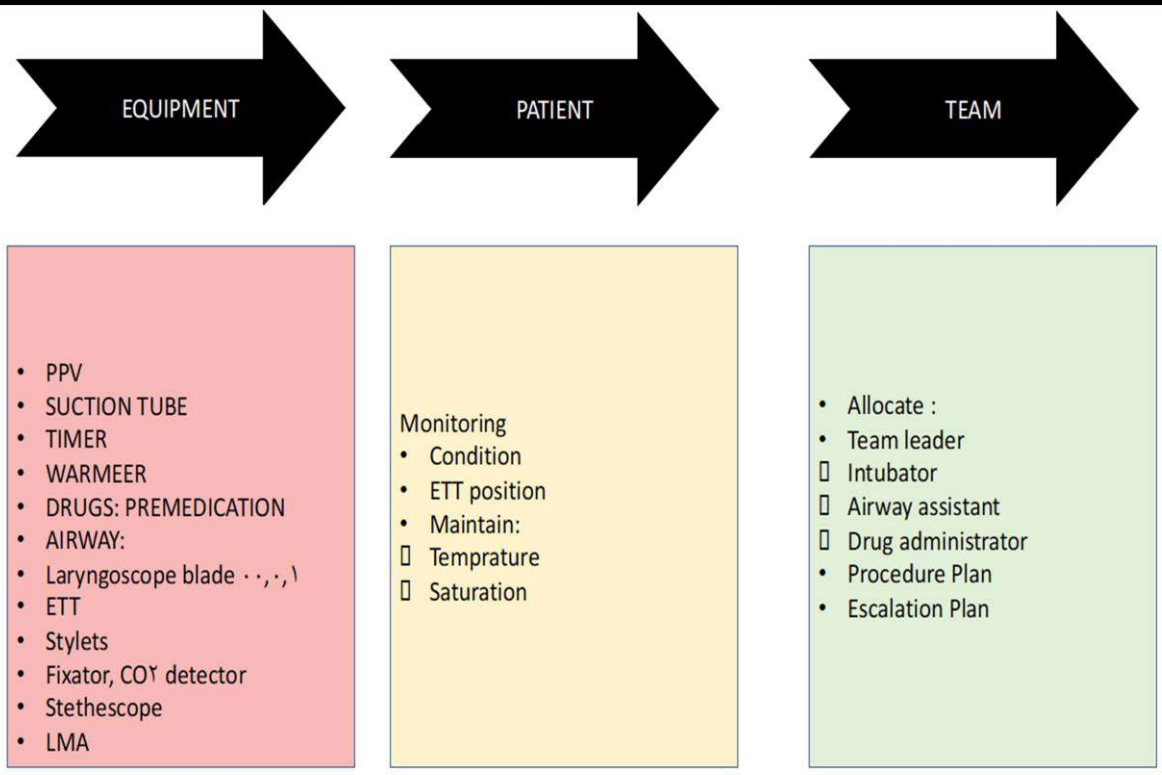
When the team are ready to begin the procedure should be carried out in the following order.

5.7.5.1 Set the Scene

5.7.5.2 Intubation structured checklist:

- Structured checklist designed to enhance organization and team communication, and ensure intubation is carried out as safely and controlled as possible. It should be attached to all airway trolleys and performed before every intubation, where time allows. It is split into three sections:
- Equipment: All essential equipment is listed and should be available and checked prior commencing the procedure, with individual adaptations appropriate for each baby and clinical setting. Equipment should be set out in a clean and sterile environment where possible in order to minimize contamination.
- Patient: The patient is fully prepared, monitored and stability maintained while preparations are completed.
- Team: To ensure the team is fully prepared, roles are allocated and a clear escalation plan is agreed.

Intubation structured checklist



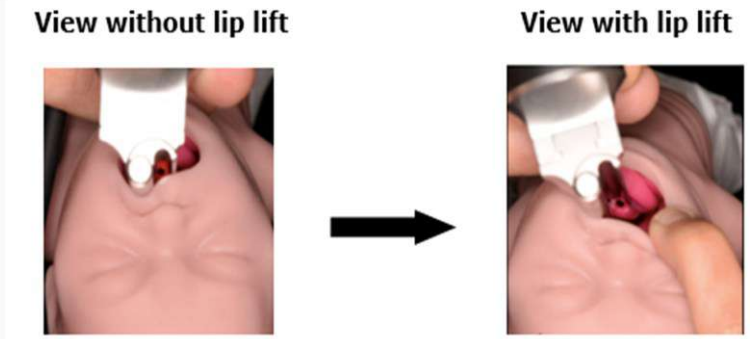
5.5.7.3 Patient optimization:

- Optimize ventilation with high flow, CPAP, neopuff or bag and mask. Aim to maintain saturations as appropriate for gestation according to NRP at delivery and take care not to hyper-oxygenate the preterm infant.
- If difficulties achieving this, ensure a MR-SOPA with an appropriately sized face mask and pay close attention to maintaining a patent airway.

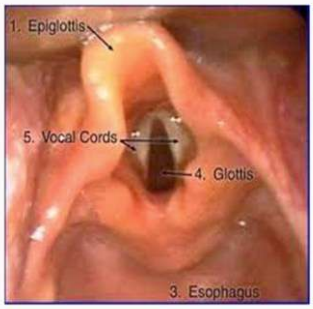
5.5.7.4 Pre-medication

5.5.7.5 Laryngoscopy:

- Holding laryngoscope in the left hand, use right hand to open the mouth wide (premedication can cause some spasm that may need to be overcome)
- Gently insert the blade over the tongue
- Use the uvula to help maintain position in the midline as indicator
- If uvula not in the midline, reposition, the scope is usually heading to left
- Advance the blade forward gently
- Lift laryngoscope handle in a forward and upward motion
- Cricoid pressure can be applied using the little finger of the left hand, or by an assistant (care should be taken not to exert excessive pressure)



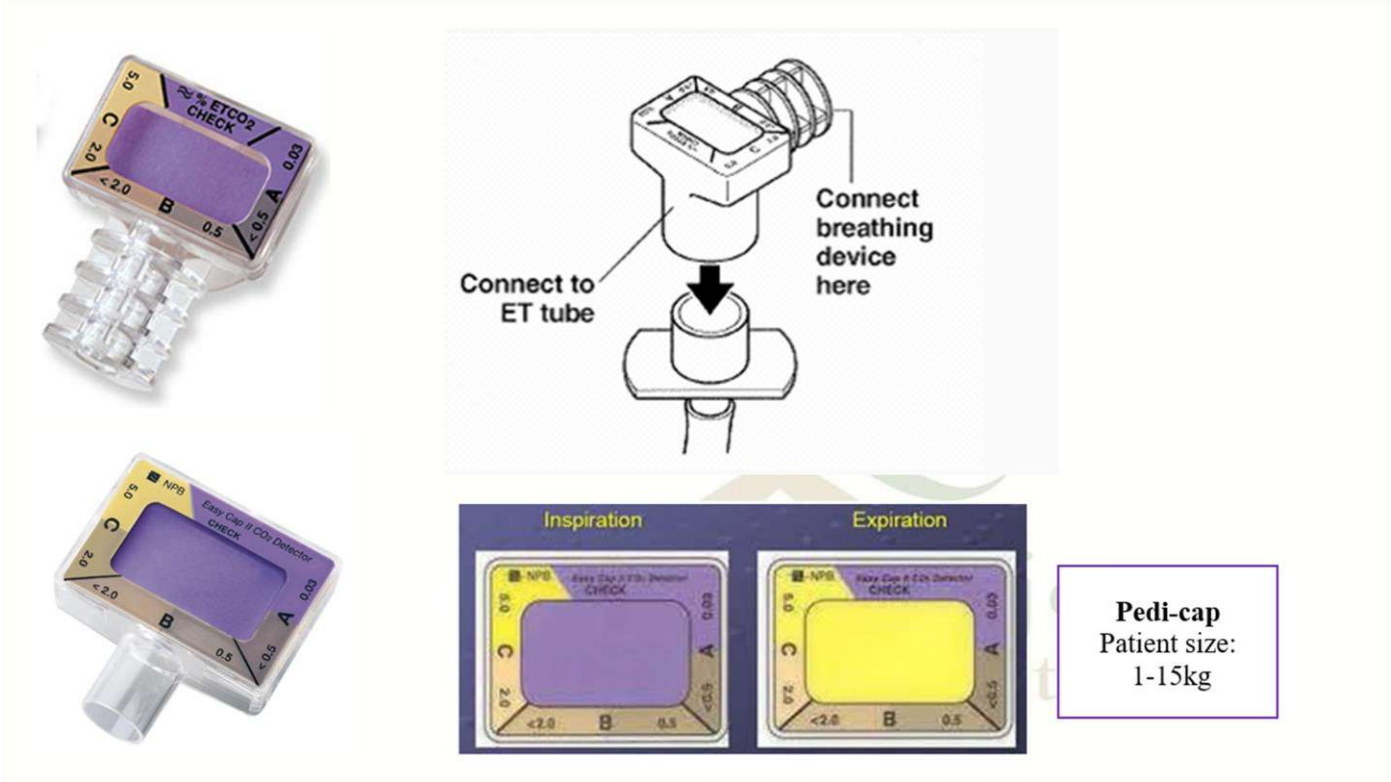
- Use suction only if secretions are impairing view
- Bring the posterior larynx and vocal cords into view, as shown below:



- Hold the tube high up and with the natural slope facing forward, as it is easier to direct
- Insert the tube in from the side to allow visualisation of it passing through the cords
- Use the black marker near the tip of the tube as a guide to depth of insertion initially
- Adjust to previously measured naso-tragal length (NTL) measurement
- Secure the ETT tube against the roof of palate or firmly at the lips
- Carefully remove laryngoscope and Stylets (if used)
- Connect CO2 detector and ventilation circuit to confirm ETT in trachea
- Secure ET with an appropriate fixation device, ensuring a good seal to the skin and avoiding traction on the ETT
- Provide PPV once ET position confirmed and throughout securing process
- Attach ETT to ventilator and adjust settings as required
- Move infant back into position carefully, ensuring ET is secure when moving infant and using a 2 person technique to avoid accidental **extubation.**

5.7.6 Confirmation of ET tube placement & secure:

End-tidal CO2 monitoring is recommended to allow immediate confirmation of a correctly positioned ET tube. This can be achieved with a colorimetric device or a side stream CO2 monitor [10,11]



5.7.8 Post procedure management:

- Chest x-ray is gold standard in confirming correct ETT position, the ET tip should be visible 1cm above carina (T2-T3)
- Consider shortening the ETT to minimize dead space
- Ensure VL blades are sent for sterilization as per unit protocol
- Ensure accurate documentation of the procedure including the position of the ETT on chest x-ray and whether or not adjustments were made
- Update parents including reason for intubation, requirement for respiratory support, safety aspects they need to be mindful of when interacting with their baby, and how they can still interact with and assist with their baby's care

5.7.9 Trouble Shooting

- If persistent leak >25% AND if interfering with ventilation, consider upsizing ET tube.
- If clinical deterioration or instability following intubation, use the **DOPE** acronym below to trouble shoot for problems: D - Displaced/Dislodged ETT, O – Obstruction, P – Pneumothorax, E – Equipment failure.

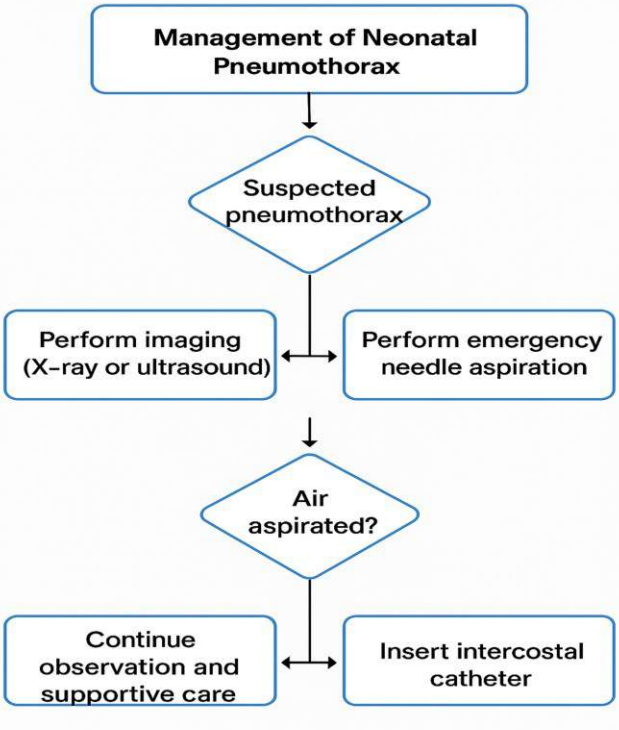
6. Responsibilities

6.1 Leader's responsibility of each health care facility to ensure full implementation.
6.2 Privileged Neonatologist or Pediatrician should be assigned by hospital to implement this Bundle Care Protocol
6.3 Privileged registered physiotherapist or privileged nurse in the NICU should follow this Bundle Care Protocol

7. Responsibilities

7.1 Pathway and Algorithms
7.2 Definitions & Severity Grading for pneumothorax

Clinical Severity	Management Recommendation
Asymptomatic / Minimal Pneumothorax	Observation and serial monitoring
Symptomatic, non-tension	Needle aspiration if necessary
Tension or hemodynamic compromise	Immediate needle aspiration, then ICC



Management of Neonatal Pneumothorax

Table1: Summary for Management of Pulmonary Hemorrhage in Neonates

Category	Actions
Initial Assessment and Stabilization	- Assess for clinical signs of PH (bloody secretions, hypoxemia, hypotension). Exclude traumatic causes of bleeding (position of ETT). - Consider early intubation and initiation of mechanical ventilation if not already intubated. - Perform chest radiography and consider lung ultrasound to assess for underlying pathologies. - Monitor continuously with pulse oximetry, blood pressure measurement, and blood gas analysis.
Mechanical Ventilation	- Secure the airway. - Increase the PEEP level to prevent further hemorrhage and improve oxygenation. - Initiate or transition to HFOV to minimize alveolar collapse and optimize ventilation. - Employ a gentle ventilation strategy to reduce barotrauma and protect fragile lung tissue.
Surfactant Therapy	- Administer additional surfactant doses once the bleeding has stabilized. - Monitor for redistribution and hemorrhage following surfactant administration.
Blood Product Transfusions	- Administer packed red blood cells to maintain hemoglobin levels. - Administer fresh frozen plasma (FFP) for coagulation factor replacement. - Give cryoprecipitate to replenish fibrinogen and other clotting factors if levels are low. - If severe platelet transfusion is thrombocytopenia is present, provide platelet transfusions.
Coagulation Support	- Administer Vitamin K if ongoing DIC is detected.
Endotracheal Epinephrine	- Consider administering endotracheal epinephrine if encountering persistent and significant pulmonary hemorrhage.
Inotropic Drug or Vasopressor	- Consider using an inotropic drug or vasopressor to stabilize cardiovascular function.
Steroids	- Consider steroids in cases of potential adrenal insufficiency.

8. Reviewer and Approval

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