the children's hospital at Westmead

# RESPIRATORY SUPPORT IN NEONATES - GCNIC - CHW

## PRACTICE GUIDELINE ©

## DOCUMENT SUMMARY/KEY POINTS

- All ventilated infants are fully monitored with alarm limits set and checked by two nurses at the beginning of each shift.
- Infants on any form of oxygen therapy require, at minimum, $SaO_2$ monitoring.
- Medical orders are required for infants on any form of ventilation or oxygen therapy. All changes in ventilation settings are recorded by the medical officer/NNP in the electronic medical record. No changes to ventilation should be made without a medical order.
- Oxygen/ventilation settings and orders are checked and documented by two nurses at shift commencement.
- Need for suctioning of ETT is determined on an individual basis based on clinical assessment.

**Key Performance Indicators**

- All new and revised respiratory support orders are written and signed by the medical officer/nurse practitioner in the electronic medical record (EMR).
- Checks are completed and documented each shift by nursing staff including review of equipment settings and oxygen





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|---|---|---|
| **Approved by:** | SCHN Policy, Procedure and Guideline Committee | |
| **Date Effective:** | 1st September 2022 | **Review Period**: 3 years |
| **Team Leader:** | Nurse Educator | **Area/Dept**: GCNC - CHW |

Date of Publishing: 15 August 2022 3:12 PM Date of Printing: 15 August 2022



NSW GOVERNMENT

# CHANGE SUMMARY

- Document format restructured and content updated
- Addition of information on fitting CPAP, BiPAP, Nitric commencement and breakout link to Nitric set-up, breakout link to CPAP application and sizing updated
- References updated

# READ ACKNOWLEDGEMENT

- All staff caring for patients that require some form of respiratory support or oxygen therapy are required to read and sign the revised policy.





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Respiratory support may take the form of mechanical ventilation, continuous positive airway pressure (CPAP), BiPAP, humidified high flow nasal cannula (HHFNC) or oxygen therapy. Support can be given via an endo-tracheal tube (ETT), nasal cannula, nasal mask or face mask.

## Documentation of Respiratory Orders

- All infants who are receiving supplemental oxygen and/or require respiratory support via an endotracheal tube, naso-pharyngeal tube or midline CPAP require a documented medical order.
- All orders are to be written and signed by the medical officer or Nurse Practitioner under in the electronic medical record.

| Component | Documentation required |
|---|---|
| Intubation | • For initial and subsequent intubation, tube change or retaping the ETT date, tube size and position are documented<br>• Any problems incurred during the procedure<br>• Any analgesia required and the infant's response |
| Ventilator Set-up | • Ventilator set up and circuit assembly or change are documented on the card on the ventilator and signed. |
| Ventilator settings (Including BiPAP, CPAP, HHFNC) | • All changes in ventilation settings are recorded in the electronic medical record<br>• The humidifier temperature, oxygen and ventilator settings are recorded on the respiratory flow chart each hour |
| Oxygen | • Oxygen therapy is ordered by the medical officer and documented in the electronic medical record |

# Oxygen Administration, Monitoring & Documentation

Infants receiving supplemental oxygen require an identified target range for $SpO_2$ delivery, to ensure adequate tissue oxygenation without the complications of oxygen toxicity.

All neonates receiving oxygen require:

| | |
|---|---|
| Monitoring, Safety and documentation | • Hourly review and documentation of: oxygen flow rate, patency of tubing/equipment, Vital signs (RR, HR, SaO2)<br>• Handover of shift equipment check documentation<br>• Oxygen saturation range<br>• Method, flow rate or percentage of supplemental oxygen administration |
| Additional assessment | • The chest assessed for bilateral chest movement and work of breathing including auscultation of air entry.<br>• Tolerance of the infant to supplemental oxygen administration during handling and after feeds. |

## Oxygen saturation targets and Pulse Oximetry[1]

Premature infants are at increased risk of developing retinopathy of prematurity (ROP), bronchopulmonary dysplasia (BPD), and cerebral injury associated with hyperoxia and the length of time for oxygen therapy[2]. Extra precautions should be taken when delivering oxygen to this population[1].

| Infants | $PaO_2$ (kPa) | Saturation range | Alarm limits |
|---|---|---|---|
| Preterm <36 weeks | 6.5 - 9.0 | 90-94% | 89-95% |
| Term(≥ 36 weeks) or post-term* | 8.0 - 12.0 | 92-96% | 90-99% |

*Unless a specifically indicated level is ordered by the Neonatologist or Cardiologist

***Patient and Carer Safety Considerations[3]***

- Ensure alarm limits are checked each shift at handover by two nurses.
- Wean supplemental oxygen if $SpO_2$ >99%

- When a monitor alarms, establish if there is a reason for the alarm i.e. deterioration, sudden event, movement artefact or monitoring lead no longer in position
- Inaccurate readings can occur when the patient is active or distressed due to anaemia, hyperbilirubinemia, lipid infusion, inotropic drugs and poor peripheral perfusion.
- Shield the probe from phototherapy lights to avoid an incorrect reading
- Re-site the probe at least every 4-6 hours to avoid pressure injuries. In poorly perfused neonates this may need to occur more frequently.

If a skin injury occurs remove probe. Check for cable damage, notify Medical Officer/NNP. An (iMS) is completed, including grading of the injury and referral to plastics considered.

## $CO_2$ monitoring

Monitoring of $CO_2$ assesses the effectiveness of ventilatory strategies and is utilised to wean support, minimise iatrogenic lung disease and prevent hypocapnia [2,4]. Continuous $CO_2$ monitoring is used as a guide to changes in the state of the lung, and can minimise the need for repeated arterial blood gas sampling[5].

ETCO2 monitoring is useful for the immediate detection of accidental extubation.

- End tidal CO2 readings are not accurate if there is moderate to large leak around ETT.
- All infants requiring invasive respiratory support require $CO_2$ monitoring.

***Establishing baseline $CO_2$***

- A correlation is established between the infant's $pCO_2$ (via blood sampling) and the $ETCO_2$ to monitor the trend of the patient's $CO_2$.
- The recommended range for $paCO_2$ is 35-45mmHg or that determined by the specific condition as guided by the Neonatologist.

## Types of $CO_2$ Monitoring

| | |
|---|---|
| End-tidal $CO_2$ (ETCO2) Monitoring[7] | • ETCO2 monitoring is the default mode for $CO_2$ monitoring in ventilated neonates<br>• $ETCO_2$ monitoring is most accurate for patients with a regular respiratory rate (i.e. sedated/muscle-relaxed) with minimal/no leak around the ETT.<br>• $ETCO_2$ monitoring may be affected by secretions or decreased tidal volume.<br>**For instructions to correlate $ETCO_2$ click** here |
| Transcutaneous $CO_2$ Monitoring | • Transcutaneous monitoring (TCM) provides a non-invasive method for monitoring oxygen tension in infants.<br>• A sensor is heated and when placed on the skin causes vasodilatation of the cutaneous vessels.<br>• TCM may be used in preterm infants or infants receiving HFOV<br>**For instructions on how to set up TCM or correlate the TCM click here** |

# Airway Adjuncts

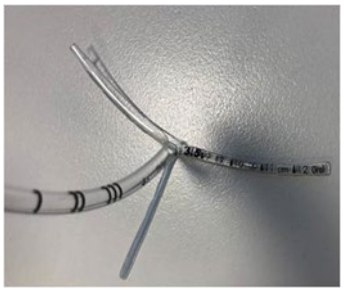
Airway adjuncts including Nasopharyngeal Tubes and Laryngeal Masks can be used in an emergency or over a longer period of time[7,8].

## Nasopharyngeal Airways/Tubes

The nasopharyngeal (NP) tube bypasses upper airway obstruction at the level of the nose, nasopharynx, or base of the tongue. The NP tube acts as a "splint" preventing the tongue from falling back on the posterior pharyngeal wall occluding the airway[9].

NP tubes are generally well tolerated by conscious infants and used in the management of congenital maxillofacial abnormalities, syndromic craniosynotosis, mid-facial hypoplasia or to support the upper airway post-surgery[6,8].

Two types of NP Airways are used in GCNIC:

| PVC Nasopharyngeal Airways | Modified Endotracheal tubes |
|---|---|
|  |  |
| PVC NP tubes are replaced every 48 hours or PRN if secretions are affecting tube patency when CPAP is in use and daily when no CPAP is used. | Modified Endotracheal Tube NP airways are inserted during LBO's via the ENT team and changed weekly |

***Safety and Precautions***

- Insertion of an NP Airway is a medical order directed by a neonatologist
- A Senior Medical Officer or Nurse Practitioner should insert the initial NPT
- Medical/NNP and nursing staff (NP/CNS/educator) that have attended training can undertake routine changes
- Occlusions may occur initially following insertion of the tube due to insertion related trauma.
- A spare NP airway of the same size is placed at the bedside.
- For additional insertion instructions for an NPA click here

***Management***

- Documentation of the tube type and size is recorded in the EMR.
- As the NPA is bypassing the route for natural humidification thickened secretions that block the NPA. The patient should be assessed regularly to review if suction is required.
- Check the skin around the nostrils frequently for blanching. Blanching leads to pressure injury/ skin breakdown and may indicate an incorrect size.
- Notify the clinical team if there is any alteration in the neonate's respiratory status.

## Laryngeal Mask Airway (LMA)

Laryngeal mask airways (LMA) are used as an alternative to intubation with an ETT tube if an airway is known to be difficult, where face mask ventilation is unsuccessful or when there have been multiple failed attempts at intubation[10].

- The LMA once inserted can be attached either to a bag and mask apparatus or to a ventilator setup.
- Use of an LMA is considered a temporary measure as the airway is still unstable and unprotected from rising gastric fluids[11]. It may provide clinicians with time during management of a difficult airway until additional help arrives.
- Failure of the LMA occurs in <1% of children and can include leak, obstruction and intolerance to the LMA[12].

| | |
|---|---|
| Criteria for use of LMA | • Difficult airway with previous difficult intubation or grade IV view where intubation attempts would be unsafe<br>• Failed intubation (3 attempts)<br>• Failure in face mask ventilation where help is not available immediately available |
| Patient and Carer Safety Considerations[12] | • Contact senior clinicians when LMA is inserted, as a more stable airway is required long term<br>• An appropriate rebreathing bag and face mask is available.<br>• Suction is checked and in working order.<br>• The resuscitation trolley is prepared with relevant equipment – pre-cut adhesive tapes, lubricant and resuscitation drugs<br>• Ensure the correct size is available (2 – 5kg = Size 1)<br>**For instructions on how to insert and LMA click here** |
| ***Assessment*** | • Review chest wall movement, improvement in heart rate and oxygenation and the chest auscultated.<br>• Utilise a Pedicap to confirm position |
| ***Ongoing Management*** | • The tube remains in-situ until a long term airway can be obtained, which should occur as soon as possible<br>• Review pain scores and analgesia requirements |
| ***Removal of the LMA*** | • Decision to cease use of the LMA should be made by the consultant, once the infant no longer requires it, or just prior to insertion of a more long term airway.<br>• Deflate the cuff<br>• Loosen and remove tapes<br>• Gently remove tube prior to exhalation<br>• Document removal and change of ventilation device in electronic medical records |

# Non-invasive Ventilation

## Nasal-Cannula Oxygen[14,15,16]

Oxygen delivery by nasal cannula (low flow) is used for infants who have reducing oxygen and flow requirements in Humidified High Flow Nasal Cannula.

- The maximum flow that may be delivered via nasal cannula is 2 litres per minute.
- Humidification is not required when administering oxygen via nasal cannula.
- Do not cut the cannula probes as the shape and length is designed for optimal oxygen delivery via the nares.

**For additional information on the Technique to apply Nasal Cannula click here.**

## Humidified High Flow Nasal Cannula (HHFNC)

Breathing cool dry gases may result in mucosal damage, reduced ciliary motility, decreased mucous production, bronchospasm and nasal discomfort[15]. HHFNC is a high flow, humidified system that delivers high flow air or oxygen with 100% humidity heating and blending of titrated oxygen via nasal cannula to patients who are spontaneously breathing[17]. This emulates the balance of temperature and humidity that occurs in healthy lungs thus maintaining mucociliary clearance and decreases discomfort and irritation.

As a consequence of flow, HHFNC produces a degree of positive end expiratory pressure which leads to improved oxygenation and reduced work of breathing[17,18].

For additional Instructions on sizing and HHFNC set up click here.

### *Indications and Contraindications for Humidified High Flow Nasal Cannula in GCNIC[17,13]*

| Indications | Contraindications |
|---|---|
| Respiratory distress or oxygen requirement up to 50% due to:<br>a) Bronchiolitis<br>b) Pneumonia<br>c) Post-extubation<br>• Weaning from CPAP<br>• Neonates >32 weeks gestation with apnoea of prematurity<br>• Neonates/infants with chronic lung disease<br>• Continuation of HHFNC therapy in transferred from PICU and other units | • FiO2 requirement > 50% (unless indicated for specialist management)<br>• Hypercapnia $pCO_2$ > 65 mmHg<br>• Respiratory Acidosis pH<7.2<br>• Nasal Obstruction (e.g. Choanal atresia)<br>• Life threatening hypoxia<br>• Use with caution in infants with gastro-intestinal obstruction or immediately following GI surgery |

**Caution**

HHFNC delivers positive pressure in a variable, relatively unpredictable and unregulated fashion[24]. Adverse clinical effects and changes in pulmonary function may result from HHFNC.

### *Nursing Care[18]*

- The neonatologist/fellow/NNP is notified prior to commencement of HHFNC.
- Each hour observe the circuit, water level and prong position. Prong dislodgement will result in a loss of respiratory support.
- Check the nares and nasal septum for signs of pressure each shift and during cue based cares, document in notes any redness or broken skin.
- Increases to oxygen concentration and flow rate are ordered by medical staff/NNP and documented in the patient's EMR.
- Observe for abdominal distension. Aspirate air from abdomen when required.
- Duoderm at the nares and use of chin strap can lead to increased pressure delivery and are not recommended.

### *Failure Criteria*

- $O_2$ demand of more than 50% requires review by medical staff or NNP.
- Changes in oxygen requirement of more than 10% require clinical review.

***Rapid clinical deterioration***

- Remove HHFNC and escalate respiratory support
- Exclude pneumothorax as a side effect of HHFNC.
- Check for nasal obstruction.

***Weaning***

- Weaning occurs when the neonate's clinical condition is improving evidenced by decreased work of breathing, normal respiratory rate range (RR), normal cardiovascular parameters and $O_2$ saturations between accepted target range of 92-96%
- Wean oxygen as required to maintain saturation range
- Wean flow as directed and tolerated by patient (normally 1L/day)
- Monitor $SaO_2$, RR and WOB after each flow change and notify medical staff/NP of any change in respiratory and cardiovascular status
- When the total gas flow is reduced to 2 L/min and $FiO_2$ is < 40% consider transfer to low flow nasal cannula oxygen.

For patients transferred to the ward varying levels of maximum HHFNC can be administered. For additional information regarding ward administration of HHFNC please refer to:

SCHN Humidified High Flow Nasal Cannula Therapy Policy

## Non-Invasive Ventilation: Continuous Positive Airway Pressure (CPAP)

Non-invasive Positive Pressure Ventilation (NIPPV) is a ventilator modality of respiratory support, given to patients without the use of an endotracheal tube. The use of NIPPV in the

NICU has increased as research shows that its use can result in the potential complications of invasive mechanical ventilation being reduced (add references below in).

The goals of NIPPV are to assist infants to maintain "normal"/acceptable physiological parameters and minimize iatrogenic lung injury from mechanical ventilation. NIV can consist of CPAP or BiPAP. CPAP may be delivered by mask in infants with upper airway obstruction or apnoea. Home CPAP is supported and managed by the Respiratory Team.

For instructions on how to size and fit midline CPAP click here.

| | |
|---|---|
| Indications for use | • Infants with respiratory distress.<br>• In the weaning process from ventilator support.<br>• Splinting of upper airway in infants with obstructive apnoea (i.e. Pierre Robin).<br>• Infants with apnoea of prematurity. |

| | |
|---|---|
| Advantages | • Preserves spontaneous breathing, does not require endotracheal intubation, and may result in less lung injury than mechanical ventilation. |

## Nursing Care[18-21]

| | |
|---|---|
| Assessing for effectiveness | • Infants are continuously monitored $SaO_2$, HR and RR.<br>• Observe for signs of decreased work of breathing, improvement in oxygen saturation and blood gases as a measure of effectiveness of the therapy.<br>• Signs of increased work of breathing, tachycardia, bradycardia, rapid shallow breathing signal the need to re-evaluate the infant's clinical condition.<br>• A pacifier may reduce pressure loss.<br>• If the secretions are thick, check the temperature and humidity level of the CPAP system. |
| Positioning and comfort | • Utilise a second person to assist you in re-positioning the infant on CPAP.<br>• Standing skin to skin transfer can be utilised.<br>• The use of comfort measures such as swaddling, a pacifier, decreasing light and noise can aid in minimising displacement due to excessive movement. |
| Protecting the skin | • Septum injury is usually the result of a combination of friction, pressure, and excessive moisture.<br>• Assess the nose regularly during your shift by removing the prongs to relieve pressure and note the size, shape and position of the nares.<br>• Check for symmetry and any skin breakdown at the nasal wall and septum.<br>• Consideration if these checks should be undertaken during caregiving (a period of additional infant activity/fatigue) should be undertaken.<br>• Ensure the face is dry before replacing the prongs.<br>• Document findings in the EMR and on NSRAS. |
| Managing gastric distention | • Some infants receiving nasal CPAP will develop gastric distension and feed intolerance. |

| | |
|---|---|
| | • Skin discolouration, absent bowel sounds, abdominal rigidity and systemic signs of illness are more likely to indicate NEC.<br>• Continuous or transpyloric feeds may be an option for infants with feed intolerance secondary to gastric distension |
| Feeding | • **There is limited evidence available regarding safe feeding practices for neonates requiring continuous respiratory support.**<br>• Consider starting with small intermittent feeds and leave the tube vented in between feeds.<br>• If there is evidence of feeding intolerance notify the clinical team. |

## Documentation

In the EMR for patients requiring CPAP/BiPAP document;

- Time commenced/any alterations in ventilation pressures or $Fi0_2$
- Size of prongs or mask, snorkel length and headgear/bonnet size used.
- Arterial Blood Gas, if clinically indicated.
- Clinical signs of improvement/deterioration.

## CPAP Complications[20-22]

If any of the listed complications occur notify the NUM/TL/Medical Officer/NP and contact the registrar:

- Pulmonary air leaks, such as pneumothorax.
- Gastric distension, therefore used with caution when there is abdominal pathology.
- Over distension of lungs.
- Nasal irritation/septum damage/forehead pressure necrosis.
- Obstruction to prongs.
- Bacterial colonization of the trachea.

# Non-invasive Ventilation: Non-invasive positive pressure ventilation (NIPPV) or BiPAP

Non-invasive positive pressure ventilation (NIPPV) applies two levels of pressure during the respiratory cycle – a pressure during the inspiratory phase that is greater than the pressure applied during exhalation[23]. This is effectively mechanical ventilation, and can unload the respiratory muscles and provide complete respiratory support. Bi-level positive airway pressure (BIPAP) is a branded/trade name (by Phillips) for NIPPV/NIV[22-24].

The goals of NIPPV are to assist infants to maintain acceptable physiological parameters and minimize iatrogenic lung injury from mechanical ventilation[23-24]. A recent Cochrane review comparing NIPPV to CPAP in preterm infants following extubation suggested a reduced need for reintubation with NIPPV.

NIPPV is NOT a replacement for endotracheal ventilation; it should be seen as alternative to CPAP.

| | |
|---|---|
| Indications for use[24,25] | • To avoid the need for reintubation in babies at high risk of BPD and recurrent apnoea.<br>• NIV facilitates early weaning strategies from mechanical ventilation |
| Advantages[24,25] | • The use of NIV instead of mechanical ventilation is associated with a lower risk of nosocomial infections..<br>• Available research also suggests the use of NIV reduces the need for re-intubation in VLBW babies post extubation. |

**Initiating Non-invasive Positive Pressure Ventilation (NIV) – BiPAP or PC-CMV on the VN500/VN800**

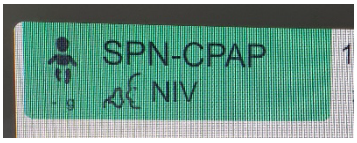
1. To use NIPPV, the ventilator is attached to the CPAP prongs or mask.
2. If the baby is currently ventilated with the VN500/800, the baby needs to be connected to the bag and offered respiratory support while setting up NIPPV.
3. Prior to beginning therapy, the non-invasive ventilation mode (NIV) MUST be selected. The therapy mode can be easily changed from “Tube” to “NIV” at the Start-Standby. Once selected, the NIV therapy mode is highlighted in orange.
4. Go to start/standby screen, go to ventilation settings and set appropriate NIPPV settings by selecting PC-CMV mode.
5. Remember to deactivate the flow sensor – the ventilator is not synchronised because there is no flow sensor.

**Complications**[23-24]

Complications for BiPAP/PC-CMV are similar to CPAP or any type of positive pressure ventilation: abdominal distension due to excess gas (similar to CPAP belly), pneumothorax, blockage of prongs/mask, nasal injury. Nursing care is managed as per CPAP care.

A "disconnection" alarm may appear on screen which typically is associated with mask/prong leak.

Please note there is a difference in screen colour for the NIV modes on the VN800 and VN500:





# Intubation and Endotracheal Tube Management

## Intubation

Nasal tubes are the preferred route of intubation for infants in GCNIC. Nasal tubes may be easier to secure than oral tubes, reduce excessive tube mobility and the risk of accidental extubation. Intubation route will be determined by the clinician intubating the patient.

An oral tracheal tube may be used for very low birth weight infants, infants with cranio-facial abnormalities, in an emergency intubation or where nasal intubation is difficult.

***Patient and Carer Safety Considerations***

- A rebreathing bag with manometer and appropriate sized face mask must be available at the bedside of ventilated neonates.
- Suction equipment is checked each shift and must be in working order. Suction catheters of appropriate size and a stethoscope should also be available at the bedside.
- The resuscitation trolley is placed at the bedside with relevant intubation equipment – appropriate size ETT, laryngoscope, Pedicap, Magill forceps and introducer, pre-cut adhesives and lubricant.
- The size of the ETT selected in patient management is directed by medical staff or NP.

**For additional information on nursing roles during intubation click here.**

# Taping of endotracheal (ETT) tubes

Correct taping of an ETT is essential to ensure tube safety and prevent accidental dislodgement. Taping of ETT is an accredited skill and must be undertaken by a staff member that has completed the NICU Skills accreditation package.

Staff should be familiar with the technique for:

- Taping an oral ETT
- Taping an nasal ETT

**For additional instruction on taping an oral and nasal ETT click here.**

## Cuffed Endotracheal Tubes

Cuffed ETTs have an advantage for some neonates requiring specific modes of ventilation[25, 26]. Cuffed ETTs are selected a half size smaller for than predicted for age to provide minimal cricoid pressure when the tube remains in-situ.

Potential advantages of cuffed ETT's include[25, 26]

- Reduced gas leak during anaesthesia and while receiving NO Therapy
- Improved ventilation and non-invasive monitoring of ventilation (capnography)
- Preferred option for certain forms of ventilation like HFOV and VG
- Decreased airway trauma and less frequent ET Tube change

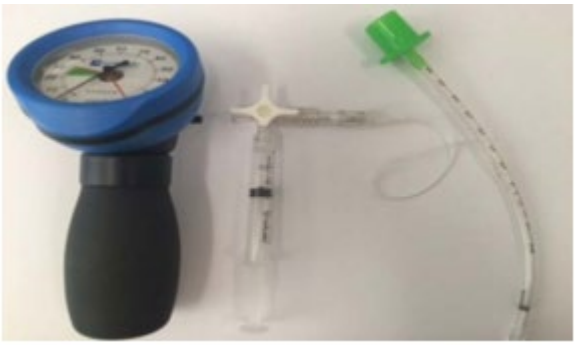
### *Insertion of cuffed ETT*

- Cuffed ETT's may be placed in operating theatre or electively in patients in GCNIC.
- Nursing staff should assess if the cuff is inflated and measure the cuff pressure as soon as possible after intubation.
- Medical staff or the NP should determine and document if the cuff is to remain inflated.
- The continued need for inflation of the cuff should be reviewed every shift by the medical team and is dependent on the respiratory status of the patient.
- The green connector will be replaced with a blue Portex connector so the in-line suction catheter can be attached and used.

### *Day to Day Management of Inflated Cuffed ETT*

- Suction oropharynx before any deflation of the cuff.
- A cuff inflation pressure of 15 cm H2O will be adequate for most neonatal patients and is the default
- After insertion of a cuffed ETT, attach the 3-way tap male end to the ETT cuff pilot tube. Connect the manometer to the next clockwise luer-lock and the 3mL syringe to the remaining luer-lock connection.
- Inflate the cuff using the syringe via the 3-way tap to a pressure of 5-15cmH2O (green zone on the manometer) to maintain minimal air leak. Close the 3-way tap after completing the measurement.
- At times the cuff inflation pressure may need to be varied. The cuff pressure will typically be in the range 10-15 cm $H_2O$, and should not exceed 20 cm $H_2O$

- Reassess the cuff pressure after the withdrawal of addition of air ensuring there is not a large leak.
- Cuff pressure should be recorded every 8 hours by manometer (stored in resuscitation trolley or GCNIC storeroom).



Picture indicating equipment required to check ETT cuff pressure.

## Suctioning an endotracheal tube

The purpose of airway suctioning is to prevent obstruction and facilitate oxygenation and ventilation. The procedure includes pre-suction assessment, preparation of equipment, performing the procedure and stabilising and supporting the infant throughout and following the procedure[27, 28].

Suctioning an artificial airway is **NOT** a routine practice and requires appropriate clinical assessment prior to undertaking the procedure.

The need for suction should be based on the following clinical assessment:

- Visible or audible secretions in the chest or endotracheal tube.
- Interpretation of clinical changes: decrease in SaO2, bradycardia, altered air entry, chest wall movement, decrease in tidal volume, coarse or decreased breath sounds. Deterioration in blood gas values

Performing the suction procedure whilst the infant is in a quiet behavioural state may result in less peripheral and cerebral circulatory instability.

### *Patient and Carer Safety Considerations*

- Suctioning is **always** considered a two person procedure. Supporting and containing the infant by a second nurse or parent has been found to reduce the effects of discomfort and procedural pain caused by suctioning [27].
- Frequency of suctioning should be determined by the infant's clinical condition and volume of secretions

- Infants who are muscle relaxed do not have the ability to cough and may be more difficult to assess for the presence of secretions, for these infants more frequent suctioning may be considered.

## Suction Technique

A closed suction technique is the preferred method of suctioning infants in GCNIC, open suction should only be considered if recommended and assisted by a CNS/NUM/NP or medical officer.

| | |
|---|---|
| Pre-oxygenation | • Is not recommended in preterm infants and infants with cyanotic heart disease[31].<br>• Consider increasing oxygen by 10% - 20% for 30-60 seconds prior to suction if the infant is already hypoxemic or has demonstrated previous hypoxemia with suctioning [30, 31, 32]. |
| Suction Depth[34, 35] | • All suctioning in GCNIC utilises the shallow suctioning technique –insertion of the catheter only to the tip of the ETT.<br>• Measure the suction catheter prior to insertion, calculate the measurement of the ETT from the point of disconnection (including adaptor) and the entire length of the tube by using a visual marking. Use the template for in-line suction catheters.<br>• Withdraw catheter slightly before applying negative suction to ensure catheter tip is not abutting the mucosa. |

For additional guidance on ETT suction utilise the ETT Suction Assessment Guide by clicking here

### *Suction Catheter size*

Suction catheter size will vary according to the internal diameter of the ETT. Catheter size has the greatest influence on lung volume loss due to airway obstruction by the suction catheter[29]. A guide for suction catheters is provided below:

| ETT Size | Catheter Size |
|---|---|
| 2.5 | FG 5 |
| 3.0 & 3.5 | FG 6 – 7 FG |
| 4.0mm | FG 8 |

## Open versus closed suction

- Closed suction technique results in an overall better physiological stability (especially in infants < 1000 grams), with less desaturation and bradycardia [29,30].
- The closed suction technique facilitates continuous mechanical ventilation (and PEEP) and oxygenation during the suctioning event[32]. It may prevent lung de-recruitment associated with the use of open suction technique, particularly in premature infants[38].
- The closed system eliminates the risk splash injury to the clinician.

**In line suction management (closed suction)**

- Ensure infant stability prior to attempting the procedure
- Attach the ventilator circuit to the larger of the two ports (perpendicular to the ETT).
- In-line suction catheters should be changed every 72 hours.

**Click here for more instructions on Inline suction technique**

| | |
|---|---|
| Suction pressure and duration | • Recommended suction pressure 10-15Kp29.<br>• On withdrawal suction should be continuous<br>• A maximum of 10 seconds is recommended for the insertion and removal of the catheter. The duration of negative suction should be no longer than 5 seconds 29, 30, 31.<br>• Individualised assessment is recommended. With one pass of the catheter and ideally not exceeding two passes. |
| Normal saline instillation | • Sterile normal saline should not be routinely[32] instilled during ETT suctioning unless directed by a senior medical officer.<br>• If Normal Saline is medically directed use 0.1– 0.2mL/kg (using a 1mL syringe) is instilled at body temperature immediately prior to the insertion of the suction catheter. |

***ETT Suspected or actual Blockage***

- If the endo-tracheal tube is blocked or is thought to be blocked call for assistance by pressing the emergency response button as the infant may require re-intubation.
- Attempt to suction the ETT tube, if necessary remove the ETT (preferably after medical or Nurse Practitioner assessment) and manually ventilate the infant with a resuscitation bag and mask until a new tube has been inserted.

## Nasal and Oral Pharyngeal Suction

Nasopharyngeal and oropharyngeal suction can be extremely stressful for the infant and should **not be** performed routinely. It is undertaken when secretions are causing physiological deterioration or distress to the infant.

*Nasal and Oral Pharyngeal suction is considered a two person procedure in GCNIC.*

- Repeated oral suction can result in oral aversion causing pain-related responses to oral stimuli or dysphagia.
- Catheters used for pharyngeal suction have a blind end and side hole, which may minimise damage to the soft tissues in the nasal/oral cavity.
- An 8FG catheter is recommended to remove the secretions adequately.
- For thick tenacious oral secretions a short 12fg catheter can be utilised to remove secretions from the mouth and shallow suction at the back of pharynx.
- The duration of oral suction should not exceed 10-20 seconds.

Document the amount, consistency and colour of secretions, the number of catheter passes and patient tolerance in the electronic medical record

# Management of the Ventilated Patient

Ventilated infants:

- Require a nurse to be in immediate attendance at all times.
- Are nursed on a memory foam mattress.
- All procedures, including suctioning, repositioning and weighing require two nurses, one of whom is experienced in caring for a ventilated infant.
- Are fully monitored with the alarm limits set and checked by two nurses at each shift change.
- Settings should not be changed without a documented medical/NP order.
- Circuits are changed every 14 days.
- Prior to connecting the ventilator circuit to the infant it is checked by an accredited staff member.

### *Assessment of ventilated infants*

At the commencement and during each shift the adequacy of ventilation should be assessed by:

- Symmetrical and synchronous chest movement
- Equal air entry on chest auscultation
- Setting and reviewing alarms and measurements for tidal and minute volumes
- Heart rate
- Skin perfusion and colour

- $CO_2$ trends
- Oxygen saturation ($SpO_2$)
- Arterial blood gas (ABG) measurement
- Reviewing Chest X-ray

- Observations are recorded hourly, monitored and assessed continuously.
- Variations in vital signs are documented in the EMR and medical staff/NP informed.
- The ETT tube is measured from nares/lips after repositioning the infant.
- The ETT and ventilator tubing should be positioned in a downward direction from the nose to avoid nostril pressure.
- Ensure at all times wheel brakes are on for all beds and standalone ventilators.
- Some form of analgesia and/or sedation is prescribed to facilitate comfort for most ventilated infants. A pain score assessment is regularly.

***Care of ventilated infants***

- The infant is positioned according to their clinical needs[33] and based on their NSRAS score.
- The circuit temperature is pre-set on the humidifier at 37'C.
- If there is excessive rainout in the circuit notify inhalation therapy or biomedical engineering as there is an issue with the circuit/humidifier.
- Ensure the flow sensor is in an upright position to prevent accumulation of water.
- Blood gases are undertaken as ordered by the medical officer/NP; or as indicated by the clinical status of the infant.
- Parents should be supported to have skin to skin cuddles as able.

***Precautions for muscle relaxed infants***

- Muscle relaxed infants require continuous monitoring with a nurse in attendance at the bedside at all times.
- Weighing muscle relaxed infants is at the request of the neonatologist and should be attended with caution.
- Ensure adequate use of analgesics.
- A liquid film gel is instilled to both eyes regularly to prevent corneal abrasions.
- Bladder catheterisation is necessary if urine has not been passed for 8hrs.

**Caveat**

Changes to ventilator settings may be required to compensate for infant instability. At these times a ventilation order is not required. Medical staff is informed that changes were made and if the settings cannot be reduced a new order prescribed in the electronic medical record.

Ventilated infants should not be bathed in a tub unless they are clinically stable and it has been discussed with the NUM/IC and Neonatologist.

# Ventilation Modes

Numerous ventilation modes are used in GCNIC for information relating to the specific modes and when they are utilised click here: Ventilation Mode Information

## Volume Guarantee

Volume guarantee ventilation adapts to individual changes in lung mechanics and respiratory drive whilst the tidal volume of the mandatory breaths remains constant. It prevents not only volutrauma but also barotrauma, as the pressure can be limited to a maximum pressure (Pmax).

| | |
|---|---|
| Advantages[34-38] | • Auto-weaning of PIP as the lung compliance improves reducing barotrauma.<br>• Reduction in duration of ventilation, IVH and air leak.<br>• $PCO_2$ stable as continuous auto adjusting occurs.<br>• Helps avoid hyper- and hypocapnoea and resulting alterations in cerebral blood flow. |
| Contraindications | • Reduced effectiveness in presence of high leak >50% - do not use. |

***Principles of Operation***

- Set a target expired VT (4-6mls/kg).
- The ventilator measures the VT for each inflation and automatically adjusts the PIP for the next breath triggered or un-triggered, aiming to deliver the VT around the set level.

***Managing VG Components***

| Component | Recommendations |
|---|---|
| PIP Limit (Pmax) | • The set PIP needs to be high enough to allow fluctuations<br>• The Pmax is determined by the neonatologist/NP.<br>• Start Pmax of 5 – 10 cm $H_2O$ above previously set PIP. |

| | |
|---|---|
| | • Adjust to 5 – 10 cm $H_2O$ once PIP established. |
| Low TV alarms | • Low TV alarm occurs if the expired TV is <90% of the set TV.<br>• For frequent low TV alarms consider ETT leak, splinting, worsening lung mechanics, air leak, or ETT tube blockage. |
| Setting Trigger Sensitivity | • The flow-sensor trigger threshold is set at its greatest sensitivity.<br>• If sensitivity is decreased, triggering is delayed and reduces synchrony between the baby's inspiration and ventilator inflation, and increases work of breathing. |
| Setting Ventilator Rate | • Volume targeting will only occur for the set rate.<br>• Spontaneous breaths in addition to the set rate are supported |
| Large Tidal Volumes | • During periods of crying, breathing hard or gasping, the spontaneous Tidal volume may exceed the set Tidal volume.<br>• VG permits infants to take large breaths however the inflation stops and the expiration valve opens if inspired VT exceeds 130% of set TV. |
| Over ventilation | If there is evidence of under ventilation consider:<br>• Patient not triggering ventilator above set rate<br>• TV set to high<br>• Excessive air leak also causes over ventilation.<br>• Check for auto triggering<br>• Wean set tidal volume |
| Under ventilation | If the infant has increased work of breathing consider:<br>• Possible air leak<br>• ETT tube obstruction<br>• Inadequate VT either due to inadequate maximum PIP (Too low to deliver desired PIP)<br>• Infant requires higher VT due to lung mechanics |

***Weaning from Ventilator (VG)***

The pressure required to deliver the tidal volume will automatically decrease as the baby's lung compliance improves (auto weaning).

- Set Tidal volumes below 3.5 mL/kg are not recommended.
- Reference to the weaning ventilation protocol is recommended

# High Frequency Oscillatory Ventilation

High frequency oscillatory ventilation (HFOV) uses a constant distending pressure (MAP = mean airway pressure) with pressure variations oscillating around the MAP at very high rates (up to 900 cycles per minute).

***Indications***

At present HFOV is only indicated as a rescue therapy for[39-40]:

1. Failure of conventional ventilation in the term infant (PPHN, MAS)
2. Air leak syndromes (pneumothorax, pulmonary interstitial emphysema)
3. Severe respiratory failure in term/preterm infant unresponsive to conventional ventilation or to reduce barotrauma when the apparent required conventional ventilator settings are deemed detrimentally high
4. Congenital diaphragmatic hernia where conventional ventilation has proven inadequate

***Haemodynamic Effects***[41]

Caution is required when HFOV is used as high airway pressure may result in impaired cardiac output and hypotension requiring inotropic support or volume expansion. If there is no improvement with HFOV, consider reverting to conventional ventilation

## Practical Management

HFOV can be delivered by two ventilators the VN500 and Sensormedics 3100A.

**The Neonatologist on call should personally supervise the initiation of HFOV**

| | |
|---|---|
| Preparation | • Infant should be intubated with minimal/no leak around ETT, use of cuffed ETT is recommended<br>• Infant should have a naso-/orogastric tube insitu<br>• Continuous IAL monitoring for MABP and ABG sampling and<br>• $TCO_2$ set up<br>• Continuous $SaO_2$ monitoring, pre- and post-ductal if PPHN is present<br>• Hypotension actively treated<br>• Muscle relaxant is indicated when respiratory effort is interfering with ventilation<br>• Sedation/Analgesia is provided indicated by the pain score |
| Commencement settings | • **Bias flow:** 20L/min (Sensormedics only)<br>• **Ti:** 33 %<br>• **HZ:** see specific conditions |

| | |
|---|---|
| | • **Paw:** Start MAP at 1-3 cm H2O above MAP on conventional ventilator<br>• Increase pressure each 10 minutes by 1 cm H2O to achieve oxygenation (recruitment strategy)<br>• Once $FiO_2$ stabilising/improving decrease pressure until de-recruitment occurs. This will allow ventilation targeting to the minimum pressure required for inflation.<br>• Maximum MAP that have been used are up to 25 cm $H_2O$<br>• **Paw limit**: Set 2 cm above and below Paw (Sensormedics only)<br>• **Power/Amplitude:** Start at twice the mean airway pressure and adjust until you have got good chest wobble |

***After Commencement***

- Observe the $TcCO_2$ and measure blood gas 30 min after starting on HFOV
- A higher amplitude will lower the $CO_2$
- Perform chest x-ray after 1 hour to ensure well expanded chest at 8 -10 posterior ribs and no air leak.
- Over-inflation is present if >10 ribs are visible and bulging of the lungs at the intercostal spaces. Under-inflation is present if there is a high diaphragm.
- Recheck ABG 30 min after each adjustment

Oxygenation and ventilation are managed independently:

| Poor Oxygenation | Over Oxygenation | Under Ventilation | Over Ventilation |
|---|---|---|---|
| Increase $FiO_2$ | Decrease $FiO_2$ | Increase Amplitude | Decrease Amplitude |
| Increase MAP*<br>(1-2cmH2O) | Decrease MAP<br>(1-2cm$H_2O$) | Decrease Frequency**<br>(1-2Hz)<br>if Amplitude Maximal | Increase Frequency**<br>(1-2Hz)<br>if Amplitude Minimal |

## Managing specific conditions with HFOV

| Condition | Management strategies |
|---|---|
| Congenital Diaphragmatic Hernia | HFOV is introduced at a lower MAP due to the infant ventilating only one lung.<br>Do not exceed a MAP of 15 cm $H_2O$. |
| Pulmonary Hypoplasia | These babies frequently fail to have a sustained response probably secondary to pulmonary hypertension and inadequate lung tissue to support gas exchange.<br>Set MAP 2 cm $H_2O$ above MAP when on conventional ventilation.<br>Frequency 10 -12 Hz. Amplitude to control $CO_2$ |
| Meconium Aspiration Syndrome (MAS) | Set MAP to the equal MAP when on conventional ventilation.<br>Set Frequency at 6 – 10 HZ, dependent on $CO_2$.<br>Use Amplitude to control $CO_2$ |
| Air Leak | Set MAP 1 cm $H_2O$ above MAP when on conventional ventilation.<br>Set Frequency 12 – 15 Hz dependent on $CO_2$.<br>Use Amplitude to control $CO_2$. |
| Term/Preterm Infant with RDS | Set MAP 2 cm $H_2O$ above MAP when on conventional ventilation.<br>Set Frequency 10 – 12 Hz.<br>Use Amplitude to control $CO_2$. |

***Weaning HFOV***

- Decrease MAP by 1 cm H2O at a rate determined by fellow/consultant/NP
- At MAP 8 -10 cm $H_2O$, $FiO_2$ < 0.4 consider changing to conventional ventilation

## Nursing Care

| | |
|---|---|
| Staff ratio | • 1:1 for infants receiving HFOV |
| Patient Assessment | Hourly assessment of:<br>• Chest symmetry including the range of chest wobble from umbilicus to clavicle<br>• Infants neurological, behavioural and pain states.<br>• Check ETT landmarks |
| Documentation | • Amplitude, Hz, FiO2 and MAP setting orders are documented in the EMR each hour. |
| Developmentally Supportive Care/Patient Management | • Ear shields/ear muffs are recommended.<br>• The infant is at greater risk for pressure areas. Memory foam mattresses must always be used.<br>• When repositioning the infant a minimum of three people are required.<br>• Weighing infants whilst on HFOV should only be undertaken following instruction from the neonatologist and should occur with a medical officer/NP present. |
| Ventilator/bed position | • The position of the bed may need to be altered when using the Sensormedics ventilator.<br>• Position the baby with their head towards the centre of the room versus traditional head to wall position<br>• Accommodate space around equipment for easy access of staff in case of emergency.<br>• A conventional ventilator is required at the bedside of the infant receiving HFOV via the Sensormedics ventilator.<br>• The brakes on the ventilator/open care system must always be on. |
| Ventilator Circuit change | • The filter in the circuit for the Sensormedics ventilator is changed every 48 hours.<br>• The ventilator circuit is changed every 14 days unless otherwise indicated.<br>• This procedure should be undertaken during a period of relative stability for the neonate and requires a minimum of 2 nurses. The medical or NP team should be notified of the procedure and may need to offer assistance. |

| | |
|---|---|
| Suctioning | • Indicated for diminished chest wall movement (wiggle), elevated $CO_2$ and /or worsening oxygenation<br>• Avoid suctioning in the first 24 hours of HFOV, unless clinically indicated.<br>• In-line suctioning must be used.<br>• For suction on the Sensormedics ventilator press the STOP button briefly while quickly inserting and withdrawing suction catheter (PEEP is maintained in the circuit) |

***Disconnection***

Disconnection of the ventilator tubing is discouraged as it can cause alveolar collapse and loss of lung volume[49,50]. Recruitment of the lung prior to disconnection may take some time to achieve and require a transient increase in ventilator settings. Use of bag and mask ventilation should be limited to mechanical, electrical failure or severe deterioration of the infant.

***Re-taping ETT***

- The inflexible nature of the Sensormedics HFOV tubing can make re-taping the ETT difficult.
- In the event a re-tape is required leave the patient on HFOV.
- Ensure adequate sedation and positioning of the head for easy access to both sides.
- Minimum of two nursing staff is required for re-taping of ETT (one must be accredited).
- The Medical officer or NP should be notified of the procedure.
- Re-recruitment may be needed post suctioning

## Troubleshooting during HFOV

| | |
|---|---|
| Low PaO2 | • Check ETT patency<br>• Check for chest movement<br>• Check for water in ETT<br>• Air leak?<br>• Suboptimal lung volume recruitment<br>• Over inflated lung<br>• Displaced tube |
| High PaCO2 | • Check ETT patency<br>• Air leak?<br>• Insufficient alveolar ventilation<br>• Chest wiggle<br>• Increase Amplitude; make sure the chest wall is moving<br>• Reduce oscillator frequency |
| Hypotension/Acidosis | • Over distended with venous return obstruction<br>• Reduce MAP<br>• Check for pneumothorax<br>• Consider the need for volume expansion and inotropes |

## Nitric Oxide[42]

Nitric oxide (NO) is an endogenous signalling molecule when inhaled (iNO) causes potent and selective pulmonary vasodilation which assists with improvement of oxygenation for infants with PPHN or secondary respiratory failure due to developmental lung diseases such as congenital diaphragmatic hernia (CDH) and bronchopulmonary dysplasia (BPD)[42].

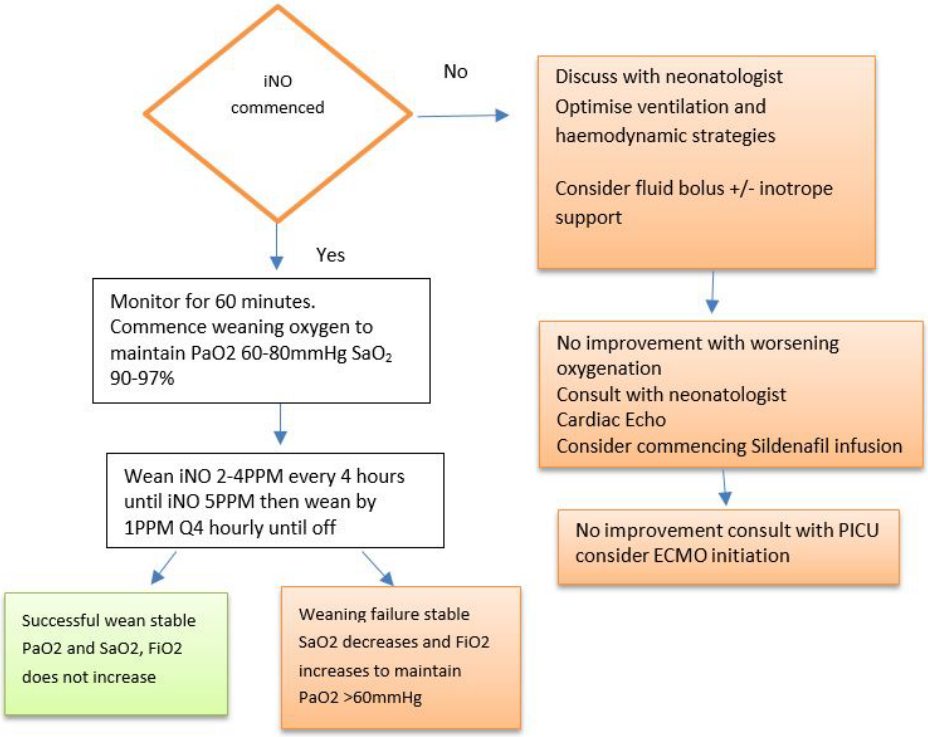
There is little evidence to support iNO use in preterm infants <34 weeks[42]. In addition care should be taken when initiating iNO in infants with severe IVH or hypoxic ischemic encephalopathy or in infants with coagulopathy.

For information on how to set up the Nitric Delivery System click here.

**The Neonatologist on call should personally supervise the initiation of iNO**

| | | |
|---|---|---|
| Starting dose | All neonates: Start with 10-20 parts per million (ppm). | |
| Assessment of response | After iNO use of 30-60 minutes medical staff to assess for response: | |
| | **Positive response:**<br>• Increase in PaO2 of ≥ 20mmHg.<br>• Or increase in Sp02 by 10%.<br>• Or able to drop Fi02 by 0.2. | **Partial response:**<br>• Increase in PaO2 of 15-20 mmHg.<br>• Or Increase in Sp02 by 5-10%.<br>• Or able to drop Fi02 by at least 0.1-0.2. |
| No response | If does not meet partial or positive response criteria discuss with neonatologist. | |

### *Management of ongoing iNO*




**Monitoring Met Hb**

Met Hb levels available via blood gas results if:

- Met Hb less than 2.5% is safe.
- MetHb 5-10% decrease iNO by 50%.
- MetHb more than 10% cease iNO. Weaning

**Weaning**

If Fi02 is less than 0.6 weaning of iNO can commence. A neonatologist may choose to wean even if Fi02 is more than 0.6 if stability in Fi02 is achieved.

In most circumstances iNO will be weaned first and then MAP. Discuss MAP weaning strategy with neonatologist/NP.

**Weaning Failure**

iNO weaning failure is defined as:

- Increase in Fi02 by more than 0.2.
- Or decrease in $Sa0_2$ by more than 5%.
- Or pre/post ductal $Sa0_2$ gradient of more than 10%.

If weaning failure occurs return iNO to previous dose then wait 4 hours before reattempting to wean.

# Weaning Ventilation and Extubation

Limiting the duration of mechanical ventilation in neonates is crucial due to the increased mortality and morbidity associated with this life saving treatment[51]. The implementation of a structured weaning protocol in GCNC led to a 30% reduction in total ventilation time.

Not all neonates will be eligible to use the weaning protocol please refer to the inclusion and exclusion criteria prior to use.

Prior to commencing weaning of a ventilated neonate a multidisciplinary assessment is performed by the primary nursing and medical staff caring for the neonate.

### *Weaning Protocol Optimisation of ventilation strategies*

To support the ventilation weaning process for neonates the following strategies are recommended:

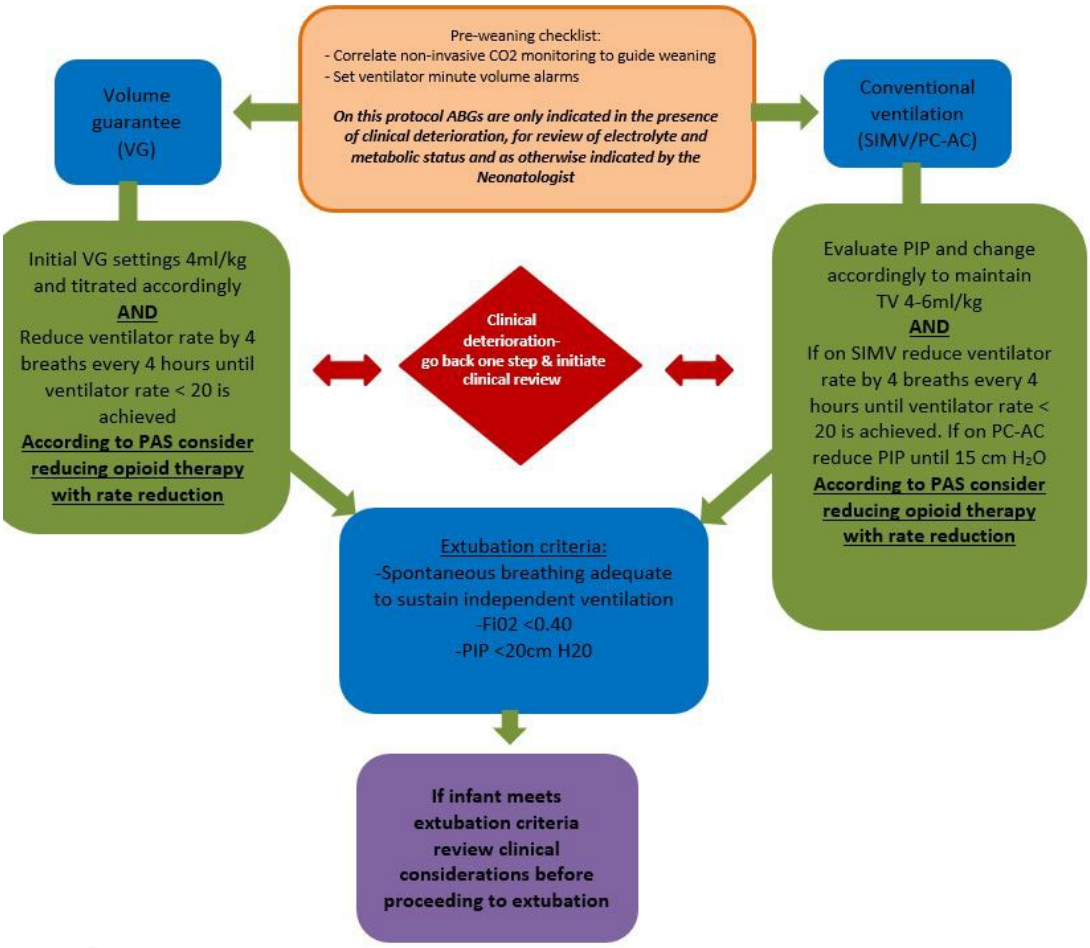
- Aim for a target tidal volume of 4-6ml/kg
- Normalise acid base balance
- Ensure adequate pain relief to achieve a PAS <5
- Correlate etCO2 with pCO2 on arterial blood gas

### *Inclusion Criteria for the Weaning Protocol*

- Acid base balance normal
- TV >4ml/kg
- Spontaneous breathing (above set rate)
- FiO2 <0.40
- PAS <5
- >32 weeks gestation
- No surgery planned within the next 48 hours
- No primary respiratory disease

If all inclusion criteria are met commence weaning protocol (see below), if not review the optimisation of ventilation strategies and discuss with the neonatologist.

For infants that do not meet the weaning protocol criteria a specific weaning plan is developed by the neonatologist for the individual baby based upon their clinical condition, underlying pathophysiology and response to alterations in ventilation.




### *Clinical Considerations prior to extubation*

- Stop enteral feeds and empty stomach contents via gastric tube
- Review respiratory effort and level of sedation
- Consult with NUM/NP/medical team regarding suitability for extubation
- Ensure neonatologist on call is aware of the plan for extubation
- Notify parents of the plan

### *Elective (planned) Extubation*

Elective or planned ETT extubation can be undertaken by accredited nursing and staff medical staff in GCNC. Elective extubations should be undertaken at time when assistance including re-intubation if required is available.

For additional information on elective extubations click here.

***Post Extubation Assessment***

- Closely observe for any signs of tachypnoea, increased work of breathing, colour changes, decreasing oxygen saturations requiring an increase in supplemental oxygen or CPAP pressure or stridor which may indicate upper airway obstruction
- Post extubation blood gases are completed at the discretion of medical staff or NP team based on the patient's clinical condition.
- Post extubation enteral feeds can be commenced after 2 to 4 hours following consultation with medical staff or NP
- Document the time of extubation, indicating if the extubation was to room air, oxygen, CPAP +/- oxygen and how it was tolerated in the patients electronic medical record
- Cardio-respiratory monitoring, oxygen saturation and the infant's work of breathing should be monitored continuously following extubation.

***Complications and causes of failed extubation include***

- Apnoea
- Hypoxia
- Respiratory acidosis
- Laryngeal oedema
- Respiratory distress
- Neurological compromise
- Bradycardia
- Atelectasis
- Upper airway obstruction
- Subglottic stenosis
- Haemodynamic instability

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