RPA Guidelines

Continuous positive Airway Pressure

Definition

Continuous distending pressure (CDP) is a method of delivering low pressure distension to the lungs during the respiratory cycle. Methods of achieving this include positive end expiratory pressure (PEEP) during mechanical ventilation, continuous positive airways pressure (CPAP) applied to the upper airway (usually nose) and continuous negative expiratory pressure (CNEP). In preterm infants the application of CDP either as CPAP of CNEP is associated with reduced respiratory failure and reduced mortality. This guideline will concentrate on the clinical application and management of CPAP and High flow as the use of PEEP is covered in the ventilation guideline.

Positive pressure therapy via a facemask was first described in 1936, in the treatment of acute respiratory insufficiency. Gregory first described its use in neonates in 1971. Since this time many devices and routes of administration have been described. Indications for CPAP have been refined and the potential pitfalls have been elucidated.

Physiological Effects of CPAP

Continuous positive airway pressure has been shown to increase arterial oxygen content. The mechanisms by which this is achieved are complex and probably due to a combination of the factors outlined below.

1. Increases functional residual capacity.
2. Reduces right to left shunting by reducing the ventilation:perfusion mismatch.
3. Decreases airway resistance by increasing pharyngeal cross-sectional area.
4. Reduces obstructive apnoeas.
5. Stabilises the respiratory rate.
6. Reduces the severity of central apnoea.
7. Protective effect on surfactant.
8. Decreases alveolar oedema.

Heated Humidified High-flow nasal cannulae

Heated Humidified high-flow nasal cannulae (HHHFNC) are gaining popularity as a form of respiratory support in preterm infants as an alternative to nasal continuous positive airway pressure (nCPAP). High flow nasal cannulae have been used as post extubation support, primary therapy from birth for RDS and ‘weaning’ from nCPAP. Definitions of high flow vary; a flow rate of > 1litre/min was used in the recent Cochrane review. The potential benefits of high flow include their easier application and greater access to the baby’s face which improves feeding and bonding. There is also a proven reduction in nasal trauma.

Several observational studies have reported that HHHFNC, at approximately 1 to 5L/min flow with appropriately sized (fill half the diameter of the nares) nasal prongs and with the infant mouth
closed, is capable of generating similar positive distending pressures to nCPAP \cite{33,34} with similar physiological effects including decreased work of breathing.\cite{35,36} However, several studies suggest that HHHFNC may provide inconsistent and relatively unpredictable positive airway pressure with little pressure developed when the mouth is left open and variable pressures developed in small infants despite the mouth being closed.\cite{35,37}

There is only one randomised trial comparing HHHFNC with nCPAP as a primary therapy for respiratory distress syndrome. The data from this trial is unpublished (Nair and Karna).\cite{31} This trial included 67 preterm infants who required nCPAP in the first 6 hours of life; the trial was ceased early due to the recall of high flow circuits secondary to \textit{Ralstonia} colonisation and bacteraemia. There is currently insufficient evidence to support its use as a primary therapy in RDS.

A Cochrane review demonstrated that HFNC used immediately post extubation may be associated with higher rates of re-intubation.\cite{30} Campbell \textit{et al} \cite{32} performed a randomised control trial comparing HFNC (humidified but non-heated) to nCPAP as post extubation support in 40 infants < 1250g. Significantly more infants receiving HHHFNC required re-intubation within 7 days, higher concentrations of oxygen and experienced more episodes of apnoea and bradycardia. These findings were not confirmed in more recent trials. Collins \textit{et al} \cite{49} found no difference in extubation failure and reduced nasal trauma in infants’ extubated to high flow nasal cannula versus CPAP. Manley \textit{et al} (unpublished) demonstrated that HHHFNC was as effective as CPAP as respiratory support post extubation in infants < 32 weeks.\cite{45}

\section*{Clinical Applications}

In view of the above evidence summary, HHHFNC will only be used as a form of weaning from nCPAP in this unit

The level of CPAP used should initially be targeted towards the condition that is being treated. A level of 5cms of water is generally the lower limit used in this nursery. This level was shown to be significantly better at preventing respiratory failure post-extubation than lower levels.\cite{29} The mean airway pressure before extubation may help target the level of CPAP to be used. Levels up to 10cms of water may be used for infants with poor lung compliance.

If the infant is commenced on a lower distending pressure and continues to have respiratory distress the pressure should be increased. If the infant continues to deteriorate the clinical situation should be reassessed and intubation considered.

Continuous positive airways pressure can be used prophylactically, when the risk of an infant developing a problem is high, or as a treatment for a pre-existing condition. The indications may be different for preterm and term infants.

\subsection*{1. Early CPAP}

There is growing interest in the use CPAP from birth in preterm infants at risk of RDS. A Cochrane review (six studies, a total of 165 infants) demonstrated that early CDP was associated with a significant reduction in the use of intermittent positive pressure ventilation and there was no evidence of effect on overall mortality.\cite{37}

Systematic review revealed only one eligible study and there was no strong evidence to endorse or refute the use of prophylactic CPAP in infants <32 weeks gestation\cite{27}. In infants born between 25-28...
weeks early nCPAP did not significantly reduce the rate of death or chronic lung disease compared to intubation and more infants developed pneumothoraces. 40

The use of very early CPAP has to be balanced against the strong evidence from systematic review that the early use of surfactant is beneficial to the infant in terms of increased survival (see Surfactant guideline for preterm infants). Until further high level evidence is available, this nursery does not advocate the use of CPAP as the primary means of support in the extremely preterm infant.

2. Treatment of respiratory distress.

- **Extremely preterm infants (<28 weeks)**
  
  See above: extremely preterm infants with respiratory distress should be intubated and given targeted surfactant early in their course (Refer to Surfactant guideline for preterm infants).

- **Preterm infants (≥28weeks)**

  If a preterm infant has good respiratory effort but has respiratory distress / apnoea the infant may be trialed on CPAP rather than intubating immediately (Refer to Conventional Ventilation guideline). Systematic review has confirmed the benefit of CPAP in reducing the rate of respiratory failure and mortality when used in preterm infants 25. Another systematic review 12 has shown further benefit to beginning CPAP early when there was clinical and radiological evidence of respiratory distress syndrome rather than waiting until there was further deterioration in terms of oxygen requirement (FiO₂ >0.5) The benefits included a significant reduction in the use of intermittent positive pressure ventilation.

### Initiation of CPAP

Thus, preterm infants (>28 weeks and <34 weeks) should be trialed on CPAP if they exhibit evidence of respiratory distress. This should be initiated earlier in their course to attain maximum benefit. In more mature babies CPAP should be given according to the likelihood of ongoing need.

### Threshold for Intubation

Preterm infants with respiratory distress (>28 weeks and < 34 weeks) should be considered for intubation and surfactant treatment if:

- Early chest x-ray is consistent with RDS and,
- Despite adequate CPAP (PEEP titrated to 8 cm H₂O in preterm babies and 10 cm H₂O in term babies) require FiO₂ >0.35 in 1st 24 hours, or
- FiO₂ > 0.4 to 0.6 after 1st 24 hours
A lower threshold may be used for intubation and surfactant for infants < 30 weeks' gestation at high risk of RDS and increasing oxygen requirements, particularly if the x-ray is consistent with RDS.

- **Term Infants**

  There is a paucity of data in the literature regarding the use of CPAP for respiratory distress in term infants. Clinical experience suggests that term infants do not tolerate the application of the CPAP devices well, resulting in restlessness and labile oxygenation (Refer to nursing policy on the management of CPAP).

3. **Post-Extubation**

When preterm infants are extubated following IPPV, nCPAP reduces the incidence of respiratory failure (apnoea, respiratory acidosis and increased oxygen requirements). This is improved further when pressures > 5 cm water are used. Following extubation:

- Infants < 29 weeks or ≤ 1250 grams have CPAP delivered by bubbly CPAP.
- Infants ≥ 29 weeks or >1250 grams may be extubated to CPAP delivered by the ventilator or via bubbly CPAP until it is clear whether the infant will have a longer need for CPAP.

4. **Apnoea of prematurity**

Observational studies suggest apnoea of prematurity is improved by the use of CPAP. However, mask CPAP using 2-5cm water pressure is less effective than methylxanthines for treatment of apnoea of prematurity. If an infant is having recurrent clinically significant apnoea, judged to be due to prematurity (i.e. not secondary to other disease processes e.g. sepsis) the infant should commence on caffeine. A trial of CPAP may also improve the clinical status (Refer to Apnoea and Bradycardia guideline). There is little data to suggest what level of CPAP should be used; >5cms water is the usual starting level at RPA.

5. **Anatomical Abnormalities / Obstructive apnoea**

Airway abnormalities that predispose to airway collapse may benefit from the application of CPAP. Distending pressure increases the cross-sectional area of the upper airways thereby decreasing the risk of obstruction.

**Treatment of Respiratory distress: Summary**

- Infants with suspected RDS < 34 weeks use Bubbly CPAP starting at 5-8cm H₂O
- Following extubation use the CPAP device appropriate for weight and maturity at a minimum setting of 5 cms H₂O; the pre-extubation mean airway pressure should be used as a guide.
Technical Issues

1. What type of prongs?

Short binasal prongs (which should rest 2-3 mm from the nares and should not be in contact with the columella) are more effective than single nasal, mask or nasopharyngeal prongs and should always be used where possible. CPAP via nasopharyngeal prongs resulted in a higher oxygen requirement and respiratory rate than CPAP with short binasal prongs.

Masks may be used when prongs do not provide an adequate seal or the nares are in need of a rest (Refer to the policy on the nursing management of CPAP).

Delivery of CPAP using a short endotracheal tube situated in the nasopharynx may be considered in infants where facial anomalies such as bilateral cleft lip / palate make use of short prongs impractical or unreliable – see policy nursing management of CPAP.

2. What type of CPAP device?

In a randomised control study comparing bubbly versus continuous (flow driver) CPAP in 140 preterm infants post extubation, Gupta et al demonstrated that they were equally effective in the management of RDS; however, if infants were ventilated for < 14 days, bubbly CPAP had a higher rate of successful extubation. Babies on bubbly CPAP also have a statistically significant reduction in the duration of CPAP support. At RPA Newborn care the following are used:

- The Bubbly CPAP circuit – this is the preferred device for infants of all gestations and for all causes of respiratory distress.
- The ventilator may be used for term or near term infants or for babies weighing > 1250g particularly if they are expected to be on CPAP for a short period of time following extubation.

3. Trouble-shooting

The best assessment of the effectiveness of CPAP is the clinical condition of the infant. If there is any doubt following thorough clinical review, blood gas measurement may help.

Oxygenation has been shown to improve with each centimetre of water increase in distending pressure applied. However at a certain point, over-distension of the alveoli will occur and oxygenation may fall. This may be due to capillary compression by the distended alveoli and subsequent shunting of the blood to an area of the lung with decreased ventilation: perfusion ratio. Therefore:

- Incremental increases in the pressure may be applied if the improvement in oxygenation is not satisfactory.
- If moderate to high levels of positive airways pressure are being used and arterial oxygen levels fall, or carbon dioxide levels rise then the distending pressure should be reduced.
4. Contra-Indications to CPAP

1. Congenital abnormalities e.g. diaphragmatic hernia, choanal atresia, tracheo-oesophageal fistula.
2. Nasal trauma/severe deformity that might be exacerbated by use of nasal prongs.
3. Cardiovascular instability is a relative contra-indication as these infants may be better stabilised by intubation and ventilation.
4. Frequent apnoea and bradycardia not responding to treatment with CPAP and caffeine.
5. Gastro-intestinal perforation

Adverse Effects

1. **Air leaks.**  
   In preterm infants with RDS the application of CPAP is associated with benefits in terms of reduced respiratory failure and reduced mortality, but an increased rate of pneumothorax. There is a risk of pneumothorax in all babies requiring ventilation or positive pressure; however, the incidence is highest in babies < 1000g. Prophylactic or early surfactant reduces this risk. Air leaks may occur due to the disease process (alveolar over distension with RDS), with CPAP particularly when the lungs are improving and lung compliance increasing. Clinical signs of air leak include increasing respiratory distress, oxygen desaturation, decreased air entry and asymmetrical chest movement.

2. **Gastric dilatation.**  
   As the continuous distending pressure is applied to the nose, the delivered gas is able to enter the stomach and GI tract. "CPAP belly" is a well-recognised phenomenon that can be reduced by the insertion of an oro-gastric tube (≥6 Fg) on free drainage. It is relatively uncommon but there is risk of aspiration, further respiratory compromise and visceral rupture.

3. **Over distension of the lung.**  
   Over distension by the use of high pressures can cause poor oxygenation and carbon dioxide retention. Cardiac output may also be reduced secondary to impeded venous return.

4. **Nasal Irritation.**  
   The fixation devices can cause irritation, damage or necrosis to the nasal septum or skin. The area should be inspected on a regular basis to avert these complications. Over-tightening of the strapping can also result in irritation and necrosis to the nasal septum (see policy nursing management of CPAP).

5. **Obstruction of the prongs.**  
   Obstruction of the prongs by secretions or other means will stop delivery of continuous distending pressure to the lungs and airways. The pressure will be maintained by the
obstruction. Humidification of gases and selective, gentle suction of the airways are important strategies to prevent this problem – see policy nursing management of CPAP.

Weaning

Jardine reviewed the evidence around weaning nCPAP and highlighted that when nCPAP pressure is weaned to a predefined level then stopped completely, it allowed for shorter duration of oxygen therapy and hospital stay compared with those infants that have nCPAP removed for a predetermined number of hours per day.

The current weaning practice for nCPAP at RPA is initially weaning the PEEP to 5cm H2O; thereafter, trialling time off CPAP as tolerated. If the baby develops an increased work of breathing, increasing levels of inspired oxygen or recurrent apnoea then nCPAP is recommenced.

A recent (unpublished) pilot RCT (60 babies) performed at this centre has demonstrated that using HHHFNC to wean babies from nCPAP is effective and is well tolerated. This study was not powered for health outcomes; however, there were no differences in length of hospital stay, chronic lung disease, duration of respiratory support and time to achieve full sucking feeds between the HHHFNC and CPAP groups. Abruptly weaning infants from nCPAP was not acceptable to some parents. There is also a proven reduction in nasal trauma.

For babies less than 30 weeks who are stable on nCPAP (i.e. meet the stability criteria below) and are likely to require at least another week of respiratory support, HHHFNC at 6L/min should be commenced. The infants HHHFNC is weaned until a flow of 2L/min is tolerated and then ceased. If a baby demonstrates 2 or more of the following failure criteria, they are recommenced on nCPAP at 5 cm H2O (can be titrated according to the clinical work of breathing or oxygen requirement) for at least 48 hours or until stability criteria have been achieved.

Stability Criteria:

- On ≤5cm H2O nCPAP (mouth closed)
- Oxygen requirement less than 25% and not increasing (FiO2 ≤0.25)
- Respiratory rate less than 60
- No significant chest recession
- Less than 3 episodes of apnoea, bradycardia, desaturations (<80% for more than 20 seconds) in 1 hour for the previous 12 hour period
- Average saturation >86% most of the time or PaO2/transcutaneous PaO2> 45mmHg
- Not currently treated for PDA or sepsis

Failure criteria (at least 2 of the following):

- Increase WOB (intercostal recession and use of accessory muscles) with respiratory rate >75
- Increased apnoea and/or bradycardia and/or desaturations >2 in 1 hour for the previous 6 hour period
- Increased FiO2 requirement >25% to maintain oxygen saturations >86% and/or PaO2/transcutaneous PaO2 >45mmHg
- pH<7.2
- PaCO2/transcutaneous PaCO2>65mmHg
• Apnoea or bradycardia requiring resuscitation

**Key Points**

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<th>Point</th>
<th>Level of evidence</th>
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<td>CPAP is effective in preventing failure of extubation in preterm infants following a period of endotracheal intubation and ventilation</td>
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**References**

17. De Paoli AG, Davis PG, Faber B, Morley CJ. Devices and pressure sources for administration of nasal continuous airways pressure (nCPAP) in preterm infants. The Cochrane Collaboration, 2008

Initial Author: Elizabeth McKechnie and Sandie Bredemeyer (2003)

Revised by Dr Tracey Lutz (2013)