East Midlands Neonatal
Operational Delivery Network

NETWORK GUIDELINE

Guideline:	**Continuous Positive Airway Pressure**
Version:	**4**
Date:	**September 2018**
Review Date:	**September 2021**
Approval:	**EMNODN Clinical Governance Group**
Authors:	**V3. T'ng Chang Kwok (ST4 Paediatrics), Shalini Ojha (Consultant Neonatologist), Anneli Wynn-Davies (Consultant Neonatologist)** **V2. Shalini Ojha (Specialist Trainee), Jon Dorling (Consultant Neonatologist)** **V1. Shalini Ojha, Diane McIness (Specialist Nurse), Jon Dorling**
Consultation:	**EMNODN Clinical Governance Group**
Distribution:	**Neonatal Units within EMNODN**
Risk Managed:	**Inappropriate use of CPAP and relevant complications, prevention of extubation failure**

This document is a guideline. Its interpretation and application remains the responsibility of the individual clinician, particularly in view of its applicability across the different Trusts in the East Midlands Neonatal Operational Delivery Network. Please also consult any local policy/guideline document where appropriate and if in doubt contact a senior colleague.

This guideline was previously a Trent Perinatal Network Guideline.

Caution is advised when using guidelines after a review date.

REVIEW AND AMENDMENT LOG

Version	Type of Change	Date	Description of Change
1	-	-	-
2	-	-	-
3	-	Aug 2017	-
4	Minor Changes	Sept 2018	TPN Guideline slightly amended for use across both North and South Hubs and transferred to EMNODN Guideline format

Background

Nasal continuous positive airway pressure (NCPAP) is used widely to provide respiratory support for preterm infants. In physiological terms NCPAP has been shown to:

- Increase functional residual capacity[1], improve oxygenation[2]
- Dilate the larynx[3], reduce supraglottic airway resistance[4] and lessen the incidence of obstructive apnoea[5].
- Improve the synchrony of respiratory thoracoabdominal movements[6].
- Enhance Hering-Breuer inflation reflex following airway occlusion[7].
- Reduce the need for mechanical ventilation and surfactant use[8].

CPAP Equipment used in the East Midlands Neonatal ODN

Several devices have been evaluated and compared for providing CPAP in preterm infants. The use of tight fitting facial masks and devices requiring a neck seal declined due to serious complications including increased incidence of cerebellar haemorrhage[7] and post haemorrhagic hydrocephalus[9]. Nasal devices remained popular and in common use as they facilitated better access to the infants and were deemed to be safer[10].

Machines can provide simple NCPAP and time triggered pressure assist CPAP based on clinician determined inspiratory time, rate and pressure in the BiPhasic mode. The later mode can also be set in BiPhasic trigger mode where the pressure assists are delivered when triggered by the baby to enable synchronised nasal intermittent positive pressure ventilation (NIPPV), a method of augmenting NCPAP by delivering synchronised positive pressure breaths via nasal prongs. The NIPPV breaths are generally delivered at pressures similar to those used prior to extubation and invasive ventilation can be mimicked by using short inspiratory time (0.3-0.5 sec) and respiratory rates of 10-60 /minute[11].

The different CPAP equipment are in regular use however there is a paucity of evidence for the superiority of one over another[12]. Short binasal prongs are more effective in preventing re-intubation than single nasal or nasopharyngeal prongs and they may be more effective in treatment of early respiratory distress syndrome (RDS)[12].

The following is a brief discussion of the equipment available in the NICUs within the Network; details of the correct way to set up these devices should be available with equipment on all NICUs.

Viasys Flow Driver

The infant flow driver delivers stable CPAP by using what the manufacturers call Fluidic Flip technology and the Coanda Effect. It can provide bi-level NCPAP and deliver sighs above a baseline NCPAP pressure. The advantage of this system is that it allows delivery of CPAP or NIPPV through the same device using soft nasal prongs. The CPAP pressure that can be delivered is 4-7 cm H_2O.

Infant Flow® SiPAP™

Infant Flow® SiPAP™ Plus provides NCPAP and time triggered BiPhasic modes with and without breathing rate monitoring. The machine also comes in Comprehensive configuration which also has apnoea backup breaths.

Patient Groups / Indications

Primary nasal CPAP for premature infants

Infants ≥ 28 weeks gestation
Positive end expiratory pressure (PEEP) can help the preterm infant to maintain residual functional lung capacity and improve lung compliance and oxygenation. NCPAP, with sufficient PEEP, applied from birth should be used for all preterm infants with signs of Respiratory Distress Syndrome (RDS).

Larger and more mature infants (≥ 28 weeks gestation) with mild to moderate RDS, who require FiO_2 ≤ 0.4 without significant respiratory acidosis (pH < 7.25) or other signs of significant respiratory distress may not require surfactant and mechanical ventilation. Infants of 28-32 weeks gestation should be intubated, given surfactant and ventilated if signs of significant RDS are present (FiO_2 > 0.4, respiratory acidosis (pH < 7.25) or clinical signs of significant respiratory distress). More mature infants (>32 weeks gestation) may be managed in relatively higher FiO_2 (up to 0.6) with normal pCO_2 and pH, particularly in the absence of significant respiratory distress.

Recommendation: Use CPAP routinely for preterm infants ≥ 28 weeks gestation who have signs of RDS

Infants < 28 weeks gestation (up to and including 27 weeks + 6 days)
(Please see the Early Care Guideline for details of respiratory management of infants born at < 28 weeks gestation.)
Evidence from recent studies[8 13-16] suggests that CPAP initiated in the delivery room (primary CPAP) may be used in place of immediate intubation and mechanical ventilation even in infants <28 weeks gestation. A meta-analysis to these studies showed that there was a moderate grade of evidence that combined outcome of death and/or bronchopulmonary dysplasia (BPD) at 36 weeks corrected age occurred significantly less frequently in infants receiving primary NCPAP from birth when compared to those who were intubated and mechanically ventilated from birth (Risk Ratio (RR) 0.89 (95% CI 0.81, 0.97) Risk Difference (RD) -0.05 (95% CI -0.09, -0.01), Number Needed to Treat (NNT) 20)[8]. However, it is important to consider that due to the need for antenatal consent, these studies may have preselected more stable pregnancies; 95% of mother's had received antenatal steroids and there were very few infants of 23 or 24 weeks gestation. The decision to use primary NCPAP in infants < 28 weeks gestation should therefore, be taken with caution, and regularly reviewed in keeping with the Early Care Guidelines.

NB: In all cases it is important to consider the overall clinical condition of the baby when deciding how to treat the respiratory distress. For example, consider early intubation in any infant who is requiring inotropic support or evidence of significant sepsis.

Recommendation: For infant < 28 weeks gesation, start CPAP at birth and carefully consider whether the infant needs surfactant and a period of mechanical ventilation. Refer to the Early Care Guideline.

Routine NCPAP and Synchronised NIPPV after extubation
Extubation of preterm infants from intermittent positive pressure ventilation (IPPV) via an endotracheal tube (ETT) incurs the risk of respiratory failure requiring re-ventilation. NCPAP (delivered by any method) reduces the incidence of respiratory failure following

extubation from IPPV and reduces the need for additional ventilatory support (RR 0.62 (95% CI 0.51, 0.76), RD –0.17(95% CI -0.23, -0.10, NNT 6 (95% CI 4,10))[17]

Preterm infants with residual lung disease may benefit from a higher airway distending pressure post-extubation; in a randomised controlled trial (RCT) of infants < 30 weeks gestation weighing 500-1000 g using NCPAP in the range of 7-9 cm of water was found to be more successful in preventing extubation failure compared to 4-6 cm of water[18]. The higher pressure CPAP did not increase the incidence of pneumothorax and did not change the duration of ventilation or rate of BPD.

Synchronised NIPPV, a method of augmenting NCPAP by delivering synchronised positive pressure breaths via nasal prongs, can further reduce extubation failure when compared to CPAP. A meta-analysis of trials[19] demonstrated a reduction in risk of extubation failure (RR 0.70 (95% CI 0.60, 0.80), RD -0.13 (95% CI -0.17, -0.08), NNT 8 (95% CI 6, 13), ten trials); as well as reduction in pulmonary air leaks (RR 0.48 (95% CI 0.28, 0.82), RD -0.03 (95% CI -0.05, -0.01), NNT 33 (95% CI 20 to 100), six trials) in infants extubated to NIPPV rather than NCPAP. However, there was no difference in the rates of BPD, death nor necrotizing enterocolitis. There were no reports of gastrointestinal perforation in any of these studies. However, these trials were a mixture of synchronised and unsynchronised NIPPV. When subgroup analyses were done on the trials that used synchronised NIPPV, synchronised NIPPV showed a statistically significant benefit for prevention of extubation failure (RR 0.25 (95% CI 0.15, 0.41), 5 trials) as well as reduction of CLD (RR 0.64 (95% CI 0.44, 0.95), RD -0.15 (95% CI -0.28, -0.02), NNT 7 (95% CI 4 to 50), 3 trials)[19]. This is supported by a recent meta-analysis by Tang et al[20] showing NIPPV significantly reduced the risk of extubation failure (Odds ratio (OR) 0.15 (95% CI 0.08, 0.31, 5 trials) and combined risk of BPD and death (OR 0.57 (95% CI 0.37, 0.88, 5 trials) when compared to NCPAP following extubation.

There is no evidence to support the use of any particular PIP levels in NIPPV; studies have suggested using PIP similar to that used during ventilation or 2-4 cm higher than pre-extubation PIP. As the pressure generated at the nasal end remains highly variable and some devices limit the maximum PIP to 11-15 cm of H_2O (11 cm in Infant Flow Advance) PIP selection should be guided by clinician preference.

Recommendation: In preterm infants, use synchronised NIPPV post-extubation. Use PEEP of 7-9 cm of H_2O for smaller infants.

For treatment of apnoea of prematurity

Recurrent spells of apnoea (pause in breathing greater than 20 seconds) are common in preterm infants: 7% at 34-35 weeks gestation to nearly 100% at infants born at < 29 weeks gestation[21]. There are no randomised controlled trials of CPAP versus no CPAP in this situation however Kattwinkel[22] in 1975 showed that the frequency of apnoea was reduced while infants were treated with CPAP.

Methyl-xanthine treatment is found to be more effective than mask CPAP for preterm infants with apnoea based on one trial that used theophylline[23]. Recent review[24] had found that caffeine citrate, another form of methyl-xanthine has similar effect on apnoea but offers advantage in its therapeutic profile with lower rates of toxicity compared to theophylline.

NIPPV may be useful method of augmenting the beneficial effects of NCAP in preterm infants with apnoea that is frequent or severe. The meta-analysis of two trials that looked at

short term (4-6 hours) effects of NCPAP versus NIPPV showed a statistically significantly greater reduction in the rate of apnoea in the NIPPV group. However this outcome was assessed in only one of the two included studies[25].

Recommendation: Consider CPAP for treatment of recurrent apnoea in preterm infants already on optimum treatment with methylxanthines. Consider NIPPV for more frequent or severe episodes of apnoea.

Contraindications for CPAP or NIPPV

CPAP or NIPPV is not suitable as a mode of respiratory support in infants with the following conditions:

- Congenital anomalies such as
  - Oesophageal atresia / Tracheo-oesophageal fistula
  - Choanal atresia
  - Diaphragmatic hernia
  - Gastroschisis
- Pneumothorax without chest drain
- Gastric perforation
- Nasal trauma/deformity that might be exacerbated by use of nasal prongs

Caution with

- NEC / abdominal surgery / abdominal distension
- Larger more mature infants may not tolerate CPAP well

Recommendation: When in doubt about CPAP indications or contraindications, please discuss with consultant.

Weaning from CPAP

While NCPAP is a relatively benign mode of respiratory support, there are on-going risks of nasal trauma and increased need for intensive care and equipment use while the infant remains on CPAP. Therefore, minimising the time spent on CPAP may be beneficial but removing CPAP too early may put the infant at risk of more frequent episodes of apnoea, increased oxygen requirement, increased work of breathing and need to restart respiratory support.

When to wean CPAP

Consider weaning CPAP when the infant required FiO_2 <0.30, pressure 5cm H_2O and well clinically.

How to wean CPAP

There is two main ways to wean CPAP, either by

- **pressure reduction** (i.e. wean pressures in steps of 1cm H_2O every 12-24 hours with plan to discontinue CPAP after 24 hours of pressures in 4-5 cm H_2O and minimal oxygen requirement).
- **Time off** (i.e. using certain number of hours off CPAP twice a day or three times a day).

A meta-analysis performed in 2011 included 3 studies which compared the gradual reduction of CPAP pressure versus increasing duration of time off CPAP[26]. The authors concluded that infants who have their NCPAP pressure weaned to a predefined level and then stopped completely have less total time on NCPAP and shorter duration of oxygen therapy and hospital stay compared with those who have CPAP removed for a predetermined number of hours each day[26]. Since the publication of this meta-analysis, one of the included studies by Todd et al[27]. has been published as a full report and the results support the conclusion of the meta-analysis. This finding is also supported by a recently published Australian trial by Tang et al[28].

Tang et al[28] also found that usage of heated humidified high flow nasal cannula oxygen (HHHFNC) may be effective at weaning infants from NCPAP with reduction in duration of NCPAP (Median 12 days versus 24 days, p=0.009, n=60). However, there was no difference in BPD, total days of respiratory support (i.e. NCPAP, HHHFNC or oxgen) and days to establish full enteral feeds.

Recommendation: CPAP can be weaned by decreasing PEEP gradually and then stopping CPAP if the infant is stable. Infants may be cycled off CPAP (predetermined time off each day) if not able to stop completely. Usage of heated humidified high flow nasal cannula oxygen (HHHFNC) may aid in weaning infants from NCPAP.

Failure in weaning CPAP

Failure in weaning of CPAP is indicated by:

- Increasing oxygen requirement
- Increasing respiratory distress
- Worsening respiratory acidosis.

These should prompt a clinical review and consider escalation of support.

Nursing Care of Infant on CPAP/NIPPV

Setting up CPAP: Step-by-Step Fixation[32]

Following this fixation technique closely helps to ensure:

- Enhanced stability of the Generator
- Minimal disturbance to the infant

WARNING: Do not attach Generator to the patient until User Verification and initial set up into NCPAP mode is complete.

Application of an incorrectly sized prong, mask or bonnet will affect stability of the generator. You may consider alternating the use of prong and mask interfaces at set intervals for a single patient in order to change pressure points on the infant's face and reduce the risk of skin breakdown.

WARNING: Infant Flow consumables are specifically designed to be used with Infant Flow Drivers and are the only consumables validated for use with Infant Flow devices.

1. Measure for prong/mask size using the nose guide. Connect the prong/mask to the generator.

NOTE**: **temporarily switching off the power to the driver while fitting the Generator to the patient will prevent alarms setting prematurely.

2. Measure for bonnet size from the middle of the forehead, around the head, to the nape of the neck and then back to the middle forehead. DO NOT use a "head circumference" measurement to determine bonnet size (it is measured in a different way)
3. Loosely weave Generator straps through the buttonholes. Begin from the inside of the colour coded buttonhole. Place the Generator on top of the bonnet above the central Velcro strip.
4. Place the bonnet onto the infant's head, checking that the ears are in a normal position. Ensure the bonnet is pulled well down over the ears and down to the nape of the neck.
5. Switch on the power to the driver and complete Set Up Screen steps to enter NCPAP mode with the prescribed settings for the current patient.
6. Lift the Generator from the top of the bonnet and bring towards the nose.
7. Gently insert the nasal prongs/mask into position while supporting the Generator. Secure the generator straps horizontally across the infant's cheeks. Do not over tighten.
8. Secure the tubes from the Generator with the central Velcro strip. Split the inspiratory and pressure lines and secure with secondary Velcro strips. Tie the open end of the bonnet if desired.
9. Final check:
    - Nose in neutral position; eyes visible; ears not folded
    - Desired upper and lower pressure levels and FiO2 are delivered
    - Infant settles quickly after fixation

On-going care
Every hour

- Check nose in neutral position; eyes visible; ears not folded[25]
- Check desired upper and lower pressure levels and FiO2 are delivered
- Record CPAP settings on Intensive Care/CPAP chart
- Check humidification chamber has sufficient water, top up if necessary
- Record observations of Heart Rate, Respiratory Rate, Oxygen Saturations

Every 3 hours (Increase frequency to 1-2 hourly if any sign of redness)
Loosen the generator straps and release the tubes from the central Velcro strip. The nasal area can be cleaned with warm water if necessary. Do not apply creams or ointments. Ensure that:

- Nasal prongs/mask is not occluded with mucus/water droplets[25]
- Patient prongs/mask and bonnet continue to fit appropriately[25].
- Re-apply the generator as described above[25].

Every 6 hours

- Record Axilla temperature
- Change baby's position; alternate between side lying and prone

Every 3 days (infection control measure)

- Replace silencer/filter, label with date/time changed and record on Equipment Tracking, Changes and Damp Dusting Record

Every 7 days (Infection control measure)

- Replace circuit and humidification chamber
- Re-measure for prong/mask size using manufacturers nose guide
- Re-measure for bonnet size using manufacturers colour coded measure
- Discard used hat, mask/prong and replace with new ones of correct size
- Record on Equipment Tracking, Changes and Damp Dusting Record

Suction

Nasal and/or oro-pharyngeal suction may be necessary if baby has a lot of secretions. Any of the following may indicate the need for suction and baby will need careful assessment: -

- Increased oxygen requirement
- Increased work of breathing
- Increased recession
- "Snuffly"
- If suction does not improve baby's condition within a few minutes then medical review is indicated

Abdominal Distension

Leave oro-gastric tube (OGT) on free drainage whilst baby is nil by mouth[26]. Once OGT feeding is commenced, aspirate air prior to each feed.

Skin Care

A recent study has shown the incidence of moderate to severe nasal trauma is common and can be as high as 50% in infants receiving NCPAP[27]. The most effective way of maintaining skin integrity is to get babies off CPAP as soon as possible. Badly fitting hats, prongs and masks may also contribute to the problem[25]. The babies most susceptible to pressure damage are: -

- Those less than 28/40 (the risk increases with increasing prematurity because of the fragility of the skin)
- Those on CPAP for a long time, particularly if they cannot manage any time off

- Assess skin integrity hourly. If baby has blanching erythema, change generator from prong to mask or mask to prong. Note how long since last change and plan to change earlier next time i.e. if blanching erythema seen after 4 hours then alternate between prong and mask 3 hourly. If baby has non-blanching erythema, ideally no further pressure should be placed on that area until it has recovered. In practice that may be difficult, so alternating hourly may be our only option.
- It is important to commence time off CPAP as early as possible – even short periods may be beneficial.
- Duoderm (or any other skin dressing that obscures direct visualisation of the underlying skin) should not be applied to the skin routinely; it **does not** relieve or protect from pressure damage. It makes observation of the skin and detection of damage more difficult. Sterile Duoderm or neopretp dressing should **only** be applied to any broken areas to protect from infection and promote healing. If Duoderm is applied to any areas of the nose, pressure relief is still the most important part of the healing process.
- Any areas of redness or breaks in the skin should be recorded

Positive Touch

- Teach parents containment holding to comfort baby
- Babies on CPAP should be stable enough for cuddles. Encourage skin-to-skin

contact. There is no set time frame; baby may stay out for as long as he keeps warm and remains comfortable and stable.

Care while on time-off CPAP

- If baby has time off, the CPAP driver should be switched off, the humidifier left on and the flow rate set to 4litres. This is to prevent stagnation of the water in the circuit and to reduce the risk of infection
- Whilst the baby is off CPAP observe for increased work of breathing; baby may tolerate less time off than was planned. A combination of one or more of the following may indicate the baby needs to go back on CPAP: increasing events, increasing respiratory rate, increasing oxygen requirement, head bobbing, nasal flaring, and increasing recession.

Once baby is off CPAP

- Monitoring to continue for minimum of 24 hours.
- If baby has been on CPAP for a short period of time, is well, >34/40 and not in oxygen then monitoring may stop after 24 hours after discussion with doctor.
- For all other babies account needs to be taken of the following: -
  - Baby's corrected age
  - Number of events
  - Continuing oxygen requirement
  - Baby on caffeine
- Capillary blood Gases done as clinically indicated:
  - Increased oxygen requirement
  - Increased work of breathing
  - Increased recession/nasal flaring

<u>Summary of recommendations and evidence</u>

Summary	Reference	Level of evidence[33]	Grade of Recommendation[33]
For infants <28 weeks gestation, start CPAP at birth and consider surfactant and mechanical ventilation if signs of severe RDS	[8] [34]	1a	A
In preterm infants, use synchronised NIPPV post-extubation.	19	1a	A
Use PEEP of 7-9 cm of H_2O for smaller infants.	18	1b	A
Consider CPAP for treatment of recurrent apnoea in preterm infants already on optimum treatment with methyl-xanthines.	23	1a	A
Synchronised NIPPV may be more effective than CPAP at preventing apnoea of prematurity	19	1b	A
CPAP can be weaned by decreasing PEEP gradually and then stopping CPAP if the infant is stable.	26	1a	A

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