Continuous Positive Airway Pressure (CPAP/BIPAP/SIPPV) use in Neonates

NHS University Hospitals of Leicester NHS Trust

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Contents

1. Introduction and who this guideline applies to;

This guideline is aimed at all Health care professionals involved in the care of infants within the Neonatal Service. The aim is to ensure all infants managed on any form of nasal CPAP/BiPAP or NIPPV receive specific considerations based on the indication for their treatment to optimise benefits and minimise complications of CPAP/BiPAP or NIIPV use in neonates.

Key Points

- CPAP is an effective method of preventing the need for intubation and of extubation failure.
- It is effective as a strategy to manage apnoea of prematurity and respiratory distress syndrome (RDS)

- High flow nasal cannula oxygen of low flow oxygen may be suitable alternatives especially for term babies, or babies weaning from non-invasive respiratory support.
- Biphasic CPAP (BiPAP) may be a reasonable step up or post extubation strategy to prevent the need for reintubation. This mode is called Non-invasive Intermittent Positive pressure Ventilation (NIPPV) on the Medin machines on NICU. Non-invasive ventilation (NIV) is not currently possible via the SLE 5000.
- Once available, newer ventilators allow use of higher pressure potentially providing opportunities for successful NIPPV in extreme preterm infants.

Background

The physiological effects of CPAP include:

- Decreased work of breathing
- Stabilisation of the ribcage reducing chest wall distortion during inspiration
- Increased efficiency of the diaphragm
- Regularisation of the respiratory rate
- Improving oxygenation[1]
- Establishing and maintaining functional residual capacity (resting lung volume at the end of normal expiration)[2]
- Lowering upper airway resistance
- Reducing obstructive apnoea[3]

Nasal CPAP is widely used for a range of neonatal respiratory conditions. It is established as an effective method or preventing extubation failure, is used in the management of apnoea of prematurity, and is increasingly seen as an alternative to intubation and ventilation for the treatment of respiratory distress syndrome (RDS).

1.1 Definitions

CPAP Continuous Positive Airway Pressure

BIPAP Biphasic Intermittent Positive Airway Pressure

RDS Respiratory Distress Syndrome

PEEP Positive and Expiratory Pressure

Fi02 Fractional Inspired Oxygen Concentration

CXR Chest X-ray

AXR Abdominal X-ray

PPHN Persistent pulmonary hypertension of the newborn
NIPPV Non-invasive positive pressure ventilation
NIV Non-invasive ventilation

Related documents:

Less Invasive Surfactant Administration (LISA) UHL Neonatal Guideline
Respiratory Distress Syndrome - Neonates at Risk UHL Neonatal Guideline.pdf
Continuous Positive Airway Pressure (NCPAP) UHL Neonatal Guideline

2. CPAP

2.1 Indications for considering CPAP

When considering if CPAP is an appropriate therapy for a baby, the differential diagnosis of the underlying cause should be considered. CPAP is an effective therapy for many conditions especially in preterm infants born below 32 weeks gestation who present with significant respiratory distress and is often started early in these babies.[4]

When starting CPAP a clear diagnosis should be sought to decide if ongoing therapy is suitable. Late preterm and term infants with significant respiratory distress are likely to have a diagnosis other than surfactant deficiency and therefore in these babies it may be appropriate to perform a CXR *before* starting CPAP.

Pneumothorax is one of the commonest causes of mild respiratory distress at term and CPAP should be used with extreme caution if pneumothorax is present.

Term babies with significant respiratory distress due to lung pathology or sepsis are at high risk of PPHN if hypoxic. CPAP can cause added distress in hypoxic term babies thereby worsening their situation. Therefore, term babies require very close monitoring and a low threshold for progressing to ventilation if CPAP is used.

2.2 Common conditions where CPAP can be effective:

- Respiratory distress syndrome of prematurity
- Pulmonary oedema secondary to patent ductus arteriosus
- Chronic lung disease of prematurity
- Apnoea and bradycardia of prematurity
- Step down weaning from mechanical ventilation

Other less common conditions may respond well to CPAP and may avoid the need for ventilation:

- Tracheo or laryngomalacia
- Post extubation stridor due to laryngeal oedema
- Diaphragmatic paralysis

In any of the above groups of babies with significant or deteriorating respiratory distress, consideration should be given to intubation and ventilation instead of using CPAP support.

2.3 Assessment after initiating CPAP

All babies requiring ongoing CPAP which is started at or soon after birth must have a CXR as soon as possible after admission to assess for the presence of a pneumothorax and any other significant lung pathology. CPAP also increases the risk of pneumothorax therefore any significant deterioration in respiratory signs or function especially in the first 24 hours must be reassessed with a further CXR.

Older babies admitted to NNU on CPAP but who have dramatically improved may be assessed for their ongoing need for this therapy. Where a decision is made that a baby does not need CPAP, a CXR may not be required, and clinical assessment of any ongoing respiratory distress is appropriate.

Babies with a pneumothorax should not be maintained on any form of positive pressure ventilation unless the pneumothorax is drained, or very close observations are made for any deterioration in respiratory function.

2.4 Potential contraindications of CPAP

Consider diagnosis and strategy in the following groups, as these babies may need ventilation in preference to CPAP.

- Babies with apnoea due to poor respiratory drive
- Term of near term babies with significant respiratory distress with rising Fi02 > 30% - these babies need consideration for surfactant and assessment for evolving persistent pulmonary hypertension of the newborn (PPHN).
- Babies managed with Less Invasive Surfactant Administration (LISA) but who continue to show significant respiratory distress or rising Fi02
- Babies at risk of PPHN e.g. showing signs of severe early onset sepsis
- Some surgical problems can be exacerbated by gaseous distention of the bowel and therefore simple oxygen therapy or ventilation may be more appropriate

2.5 Absolute Contraindications to CPAP

- Established PPHN – these babies need aggressive management to prevent the downward spiral of hypoxia and worsening PPHN. They should be intubated and ventilated.
- Congenital diaphragmatic hernia
- Apnoea

2.6 Babies less than 32 weeks gestation

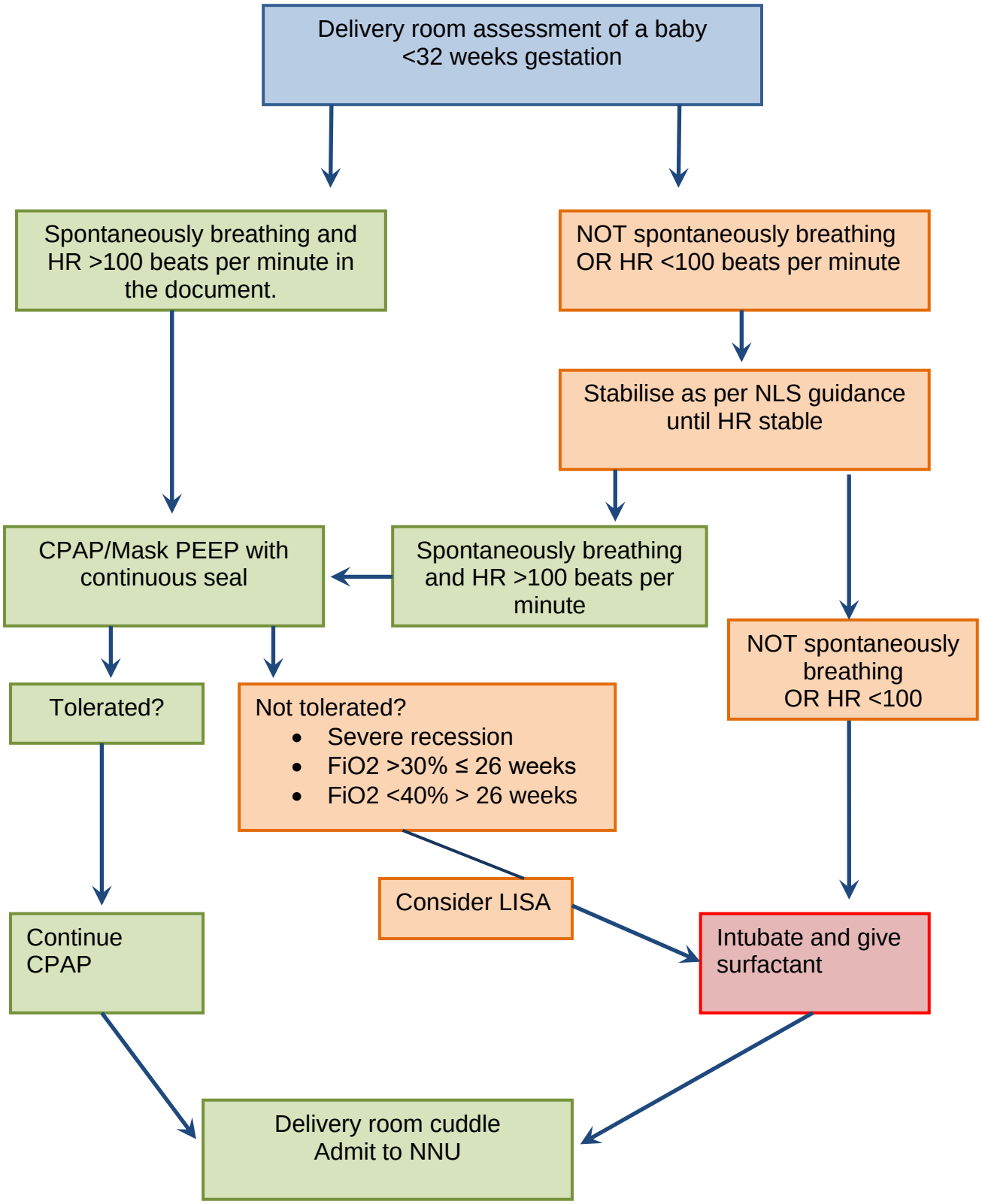
Babies at risk of respiratory distress syndrome should be commenced on facial CPAP at birth. [5-8] Care should be taken to ensure a continual delivery of this therapy with minimal breaks in maintaining a seal via a mask as a baby is assessed and transferred to the CPAP driver. Further assessment of their requirements for respiratory support should be made with facial CPAP ongoing and the need for intubation considered.

Provision of CPAP in delivery suite should not preclude the opportunity for a delivery room cuddle once the baby is stabilised and the CPAP interface is securely in place.

Please refer to guideline UHL **Respiratory Distress Syndrome - Neonates at Risk UHL Neonatal Guideline.pdf**

Flow Chart 1: Assessing Preterm Babies < 32 weeks for CPAP in Delivery Suite

ASSESSING BABIES IN DELIVERY SUITE FOR CPAP



2.7 Management of preterm babies Needing Early CPAP

- Put the baby on CPAP before inserting lines and aim for a PEEP of at least 6cm H2O. If using a Medin CPAP driver (Mini or NC3) – switch on leak assist.
- Insert IV cannula and take any necessary bloods
- Start IV fluids, and give IV medication
- Arrange an immediate CXR to assess lungs and exclude pneumothorax – this cannot wait 4 hours
- Delay any invasive procedures except drainage of a pneumothorax until the baby has stabilised
- Allow permissive hypercapnia ($PaCO_2$ up to 9 kPa on a capillary blood gas) as long as the pH is above 7.20. If in doubt about the validity of a PCO2 on a capillary sample – check an arterial gas. This is a painful procedure and should only take place if absolutely necessary.
- Late preterm babies may benefit from early CPAP but there is often time for assessment of the effectiveness of breathing in delivery suite before initiating CPAP. Most babies will respond to a short period of facemask PEEP.

2.8 Considerations in term babies

The differential diagnosis of the commonest causes of respiratory distress in term babies is different to preterm infants. A history of antenatal and peripartum events is important in ascertaining likely causes.

CPAP may not be well tolerated and can exacerbate some conditions. It is **rarely needed** from birth and babies with a good respiratory drive can usually be admitted to NNU from delivery suite in incubator oxygen.

If baby is requiring >40% oxygen and especially if increasing FiO2 or high work of breathing, consider early intubation.

Babies admitted straight after birth should be observed closely before respiratory support is started as they may settle with conservative therapy.

Babies improving whilst not on respiratory support and with normal blood gases including blood sugar may not need starting on IV fluids immediately.

CPAP (by nasal prong or face mask) should be used with caution in term babies as it is associated with the exacerbation of pneumothorax. It is preferable to use facial oxygen or high flow nasal cannulae where possible.

Should CPAP be commenced in delivery suite with a plan to continue on admission, an **URGENT** CXR must be obtained and cold light examination performed.

Start intravenous fluids only when a baby appears unwell or has a low blood sugar. A baby with mild or rapidly settling respiratory symptoms may be suitable for early oral feeding.

Review regularly for improvement or deterioration. If there is improvement, aim to reunite mother and a term baby as soon as possible. If the baby deteriorates escalation of therapy may be necessary according to unit guidelines and senior review**.**

2.9 Possible Failure of CPAP

- If improvement does not occur, check the application of the interface is good and that the baby is receiving the desired CPAP pressure. Some babies may benefit from escalation to NIPPV/BIPAP or administration of rescue surfactant (200mg/kg) with either intubation & ventilation or use of the LISA technique [Ref 1-3], .
  Please refer to - **Less Invasive Surfactant Administration (LISA) UHL Neonatal Guideline**

- Pneumothorax is a contraindication to BIPAP unless baby is very closely monitored or it has been shown to be successfully drained by a recent CXR in a stable baby. (FiO2 < 30%).

2.10 Biphasic PAP (BiPAP or NIPPV)

There is emerging evidence that non-invasive ventilation (NIV) or non-invasive positive pressure ventilation (NIPPV), whether synchronised or not, may reduce the need for mechanical ventilation or extubation failure in preterm infants at risk of BPD.[9-11] Older studies using machines that generated mean airway pressures <10cm H2O did not show a benefit of Biphasic CPAP over nasal CPAP but newer modalities and machines have shown more promising evidence.[11] It is not yet understood whether the benefit is gained by simply achieving a higher and more reliable mean airway pressure or whether it is the biphasic pressure change itself that confers benefit.

2.10.1 Indications:

- Clinical evidence of possible decruitment on CPAP
  - Ensure the following have been assessed:
    - seal on the nasal interface on CPAP is secure
    - good CPAP pressures of at least 6cm H2O are being achieved
    - leak assist function has been used
    - Oral and nasal care minimises build-up of secretions
  - If the baby continues to show signs of respiratory instability, BiPAP/NIPPV can be considered.
  - Babies should be assessed regularly for the ongoing need for BiPAP/NIPPV

- Step down from ventilation where there is a high risk of extubation failure
  - Babies with significant lung disease especially extreme preterm infants and those requiring higher FiO2 (>30%), history of extubation failure or with interstitial lung changes on XR may benefit from initially being extubated initially to BiPAP/NIPPV. Where there are no episodes of apnoea or significant instability following extubation onto BiPAP, step down to CPAP after 12 - 24 hours can be considered.

2.11 Deterioration on CPAP/BIPAP/NIPPV

2.11.1 Clinical signs

This may be evidenced by:

- Rising oxygen requirements

FiO2 continuing to rise > 30% - consider LISA in babies who have not received surfactant and in whom a CXR has confirmed the likely diagnosis of surfactant deficiency.
N.B. higher levels of FiO2 may be permitted in stable babies with evolving or established chronic lung disease post extubation.

- Respiratory acidosis: capillary pH <7.20 with a rising pCO_2 >9.0kPa (capillary gas). Arterial PaCO2 (if checked) should ideally be < 6.0Kpa.
- Development of recurrent apnoea requiring stimulation
- Development of spontaneous episodes of significant desaturation
- Worsening respiratory distress (sternal and/or intercostal recession, grunting, tachypnoea)
- Agitation not relieved by simple measures (comforting, paracetamol) – this is particularly important in more mature babies as distress and the resulting hypoxia can precipitate the onset of pulmonary hypertension.
- Development of a pneumothorax (CPAP is a type of positive pressure ventilation; therefore babies with a pneumothorax on CPAP need a chest drain in the same way as they would do if they were intubated and ventilated.)

2.11.2 Trouble shooting poor gases

The following should be checked:

- The prongs are in the nose and are the right size
- Leak assist is switched on in CPAP mode (Medin Mini) and in all modes (Medin NC3)
- Pressures of 8 to 9 cm water have been tried
- Pneumothorax is not present
- The neck is slightly extended
- The nose has been cleared (suctioned carefully and thoroughly)
- The mouth is closed or baby has a dummy
- Auscultation should demonstrate good air entry
- Nursing aspects of CPAP are in place and effective (see below)
- Biphasic CPAP has been tried – a CXR (if not recently taken) at the time of escalating to BIPAP is indicated.

2.12 Complications of CPAP

- Traumatic injuries to the nose and face from prongs can occur, and although these can be minimised by good nursing care, they are not completely avoidable. Please refer to - **Continuous Positive Airway Pressure (NCPAP) UHL Neonatal Guideline**
- Pneumothorax – CPAP should not be used in the presence of an undrained pneumothorax without very close observation. Pneumomediastinum is not a contraindication but a baby should be monitored closely with a very low threshold for the review of use of CPAP
- Abdominal distension – occasionally babies may appear to develop gaseous distension of the abdomen. CPAP is not associated with increased incidence of NEC. A pragmatic approach is required and it is important to ensure the following:
    - Drainage of air from the NGT by regular aspiration or by leaving the NG open to air between feeds.
    - Baby is opening bowels sufficiently – a glycerine chip may be considered if BNO for > 24 hours and baby symptomatic
    - A trial off feeds may be the only option to try and clarify the cause of the distension.

2.13 Weaning of BiPAP and CPAP

2.13.1 Weaning BiPAP to CPAP

When weaning BiPAP, consider reducing PIP pressures steadily by 1cm H2O until a pressure of 10/6 being used. At this point a trial of CPAP is appropriate. Some babies may tolerate a simple switch of modalities.

2.13.2 Weaning off CPAP

- After 24 to 48 hours of stable CPAP, all babies should be assessed regularly and ***may*** benefit from a switch to humidified high flow nasal cannula oxygen. If the baby is to stay on CPAP this should be an active decision and will be based on the underlying diagnosis.
- Not all babies on CPAP require weaning to high flow nasal cannula support.
- In more mature babies or those who have minimal symptoms, a trial off CPAP breathing room air or low flow O2 / Head box O2 may be appropriate.

2.14 Summary of CPAP Modes

NCPAP	Constant, stable single level positive pressure.
NCPAP with Apnoea	All the advantages of nasal CPAP, with the additional benefit of apnoea monitoring. The abdominal respiratory sensor detects apnoea; additional pressure is administered to stimulate breathing during an apnoeic episode.
BiPAP/NIPPV	Time cycled pressure assists are delivered based on clinician set inspiratory time, rate and pressure criteria. It is a timed bi-level pressure rise above the baseline CPAP. Small incremental pressure increases of 2-3cms H_2O augment functional residual capacity and in theory can offload the respiratory work of breathing
BiPAP/NIPPV with Apnoea	As Biphasic with additional benefit of apnoea monitoring and pressure stimulation when apnoea is detected

8. Process for monitoring compliance

Through Neonatal audit plan

9. Education & Training

None

10. References

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11. Keywords

Continuous Positive Airway Pressure, Biphasic Intermittent Positive Airway Pressure, Respiratory Distress Syndrome, Positive and Expiratory Pressure, Fractional Inspired Oxygen Concentration, Chest X-ray, Abdominal X-ray

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The Trust recognises the diversity of the local community it serves. Our aim therefore is to provide a safe environment free from discrimination and treat all individuals fairly with dignity and appropriately according to their needs.
As part of its development, this policy and its impact on equality have been reviewed and no detriment was identified.

CONTACT AND REVIEW DETAILS			
Guideline Lead (Name and Title) J Preece – Consultant Neonatologist			**Executive Lead** Chief Medical Officer
Details of Changes made during review:			
Date	**Issue Number**	**Reviewed By**	**Description Of Changes (If Any)**
April 2023	**1**	**Neonatal guidelines group** **Neonatal Governance group** **Women's Q&S Board**	**New guideline**

Appendix 1: Machine options for CPAP BiPAP and NIPPV and settings to use

CPAP

CPAP – using Medin mini

Set desired CPAP pressure to deliver a constant CPAP flow. The Medin Mini only has “leak assist” function in this mode which should be manually added and ensures the flow is adjusted automatically to achieve the desired CPAP. If any changes are made to settings, the leak assist may require resetting manually.

CPAP + Apnoea using the Medin Mini/NC3

In this mode the baby will receive regular “breaths” at a preset rate after a period of Apnoea. The baby’s breathing is detected by the by the pressure variation between the inspiratory and expiratory limb so an abdominal sensor is not required.

To activate CPAP + Apnoea – press the mode button, then the CPAP button and confirm.

When activating CPAP + Apnoea – additional setting options appear where the inspired time (Ti), rate and apnoea time can be set (this should be at least 20 seconds). The additional flow delivered is determined by the Finsp setting as for NIPPV (BiPAP) mode.

CPAP + Apnoea mode requires a good seal and for the desired CPAP pressure to be achieved. If there is significant leak around the nasal interface, spontaneous respiration will not be detected and the machine will assume apnoea. Ensure the interface is well fitting and that the CPAP pressures generated are close to the flow set i.e. 8L/min should create 6-8 cm H2O pressure.

In very small babies where the flow generated by spontaneous respiration is very low, the sensitivity setting for the apnoea trigger may need to be reduced.

CPAP using SiPAP or Arabella

Both devices can deliver flat CPAP. If a baby needs escalation to biphasic CPAP then there should be consideration of changing the device to one that can deliver NIPPV. If these are not available then the SiPAP device can be used to deliver biphasic CPAP. These machines are being phased out in 2023.

BiPhasic PAP (BiPAP or NIPPV)

NIPPV (BiPAP) Using Medin Mini

The NIPPV function on both Medin machines is limited by the pressures that can be generated and maintained.
The NIPPV function on a Medin CPAP driver can be useful for babies with reasonable respiratory drive but where there is a risk of atelectasis. In the NIPPV (BiPAP) mode, a long

inspiratory time and low rate allows a baby to breathe through the prolonged inspiratory phase of the higher level of the biphasic pressure changes.
The most effective strategy aims to aid recruitment and prevent atelectasis.

i. Pressures are generated by changes in flow throughout the respiratory cycle. A good seal is important to ensure pressures are delivered as desired.
ii. The rate set is mandatory (regular) and not synchronised with the baby's respiratory rate but the aim is for the baby to breath as normal through the periods of higher pressure.

Recommended Initial settings on the Medin Mini/NC3:

- Set flow (L/min) to the desired CPAP pressure required. Adjust according to CPAP generated. Read this from the single number at the top right of the screen.

- Set inspiratory time 0.7 – 1 second

- Set additional flow (labelled as *Finsp or Vinsp*) to achieve a higher BiPAP pressure at least 4 cm H2O above the CPAP pressure. Read the generated pressures on the flow wave part of the screen and adjust *Finsp* to achieve the desired pressure – usually requires at least +2 L/min but may need + 4L/min. Aim for PIP of 12 – 14. Above this level the machine may go into safety mode with a red alarm (see below).

- Rate – automatically set at 30 breaths/minute when the Ti is 0.7 seconds. If the inspiratory time is increased to above 0.7 seconds the machine will further limit the possible rate delivered with these longer inspiratory times.

- A lower inspiratory time will allow a faster rate to be used but this will then restrict the pressures generated. Pressures generated are not sufficient for effective NIV.

- Add the Leak assist function if using the NC3 (not available in NIPPV mode on the Mini)

- As the inspiratory time is reduced the machine will not automatically increase the respiratory rate – this needs to be altered manually.

Inspiratory time (seconds)	Maximum rate permitted (breaths/minute)
0.4	50
0.5	45
0.6	40
0.7	30
1	20
2	10

<u>Safety Mode</u>

- The machine has a safety limit of 18cmH2O and will switch into safety mode and activate the "red alarm" if these are reached. As a baby moves and splints against the

CPAP, this pressure limit is easily reached. Triggering this safety function is more likely if the flows are set high enough to create a BiPAP pressure >14cm H2O.

- The machine comes out of safety mode and resumes NIPPV/BiPAP if the pressures at the nasal interface drop but the “red alarm” needs to be manually reset.

Biphasic CPAP (BiPAP) using the Infant Flow SiPAP

- The SiPAP machine should ideally only be used to delivery simple CPAP
- For BiPAP the required pressure is set on the SiPAP machine using the flow meters.
- This machine can only generate modest BiPAP pressures and breaths can be synchronised in the trigger mode.
- The SIPAP machine generates an effective simple CPAP but does not have leak adjust or flow compensation if a seal is lost.