CONTINUOUS POSITIVE AIRWAY PRESSURE (CPAP)

DEFINITION
Method of maintaining low pressure distension of lungs during inspiration and expiration when infant breathing spontaneously

Benefits
- Improves oxygenation
- Maintains lung volume
- Lowers upper airway resistance
- Conserves surfactant and reduces alveolar fluid

INDICATIONS
- Early onset respiratory distress in preterm infants (<34 weeks gestation) with good respiratory effort
- Can be helpful in respiratory distress in infants of >34 weeks gestation, especially with clinical features of RDS. Perform a chest X-ray to confirm RDS and exclude pneumothorax
- Recurrent apnoeas in preterm infants
- Atelectasis
- Tracheomalacia
- Respiratory support following extubation (see below)

CPAP following extubation
- Use for majority of infants of <32 weeks, after loading infants with caffeine
- Use ‘Rescue’ CPAP for other infants who have apnoeas or desaturations and an increasing oxygen requirement within first few hours after extubation
- Apnoea and desaturations appearing later than first few hours after extubation can be an indication for CPAP but also consider an additional underlying clinical condition (e.g. sepsis)

CONTRAINDICATIONS
- Any infant fulfilling the criteria for ventilation
- Irregular respirations
- Congenital anomalies:
  - diaphragmatic hernia
  - choanal atresia
  - tracheo-oesophageal fistula
  - gastroschisis
- Pneumothorax without chest drain
- Nasal trauma/deformity so severe that it might be exacerbated by use of nasal prongs
- Cardiovascular instability is a relative contraindication as intubation and ventilation may allow better stabilisation
- Larger babies often do not tolerate application of CPAP devices well, resulting in restlessness and labile oxygen requirement

When in doubt about CPAP indications or contraindications, discuss with consultant

TYPES OF CPAP
1. Standard CPAP
2. Assisted CPAP via infant flow driver (if available locally)
3. Bubble CPAP (if available locally)
1. STANDARD CPAP

Equipment
- Short binasal prongs and/or nasal mask
- Circuit
- Humidification
- CPAP generating device with gas mixing and pressure monitoring
- All require high gas flow and can pose problems for transportation

Fixing nasal CPAP devices: short binasal prongs (preferred)
- To avoid loss of pressure, use largest prongs that fit nostrils comfortably
- Ensure device is straight and not pressed hard against nasal septum to avoid damage to nasal septum and lateral walls of nostrils. Excessive pressure can cause septal erosion

Fixing nasal CPAP devices: nasal masks
- Fit securely over nose
- Consider alternating with binasal prongs, particularly if infant developing excoriation or erosion of nasal septum
- Masks can give a poor seal and tend to obstruct
- They can result in trauma, usually at junction between nasal septum and philtrum

Flow rates
- The usual starting rate is 8 L/min. Aim to keep flow to a minimum, but too low a flow rate increases the work of breathing
- With both prongs and masks, flow required is affected by degree of ‘leak’ of gas from nose and mouth. Aim to keep mouth closed to maintain pressure in pharynx. Support chin and/or use a preterm pacifier to try to keep mouth closed

Procedure
Position baby
- Prone position is preferable, as it reduces central and mixed apnoeas
- Avoid excessive flexion, extension or rotation of the head

Set up equipment
- Connect humidification to CPAP (see manufacturer’s instructions)
- Connect CPAP circuit with prongs to CPAP device
- Place CPAP hat on baby
- Attach CPAP circuit to CPAP hat and place prongs in nostrils as above
- Turn on CPAP flow and set pressure (see below)

Pressure range
- Optimum pressure depends on illness type and severity, but use 5 cm H2O initially
- Increase by 1 cm H2O increments
- Watch baby, and use lowest pressure required to improve work of breathing

High pressures (≥10 cm H2O) may restrict pulmonary blood flow, increase air leak risk, and cause over-distension and later hypercapnia

CPAP ‘failure’
CPAP ‘failure’ implies a need for ventilation. Consider intubation and surfactant for preterm infant (≤34 weeks gestation) on CPAP as initial therapy if:
- Early chest X-ray shows RDS and one or more of the following apply:
  - FiO2 consistently >0.6
  - marked respiratory distress e.g. marked intercostal and subcostal recession, suggesting infant likely to tire quickly
  - persistent respiratory acidosis with arterial pH <7.25 and PaCO2 >8.3 kPa/60 mmHg
  - recurrent serious apnoeas
  - irregular breathing
Checks
- Before accepting apparent CPAP ‘failure’ exclude:
  - insufficient pressure
  - insufficient circuit flow
  - inappropriate prong size or placement
  - airway obstruction from secretions
  - open mouth
  - pneumothorax

Complications
- Erosion of nasal septum: reduced by careful prong placement
- Gastric distension: benign, reduced by leaving nasogastric tube open

Weaning CPAP
When
- Do not wean CPAP until infant consistently requiring \( \text{FiO}_2 < 0.35 \) on CPAP of 5 cmH\(_2\)O
- it may be necessary for infants developing excoriation and/or erosion of nasal septum to come off CPAP for short periods at regular intervals before weaning to enable healing

How
- Infants of >29 weeks gestation at birth and >1250 g may be weaned off nasal CPAP into nasal cannula oxygen or air. Other infants may need to cycle on and off CPAP
- The following regimen of cycling CPAP can be adapted to individual cases, as rate of weaning will depend on individual baby
- Slow weaning is advised for preterm infants with atelectasis and/or apnoeas, or poor growth. Such infants would spend longer at each stage of the weaning regime

<table>
<thead>
<tr>
<th>Day</th>
<th>Off CPAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 1</td>
<td>1 hr off twice a day (1 off, 11 on)</td>
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<tr>
<td>Day 2</td>
<td>2 hr off twice a day (2 off, 10 on)</td>
</tr>
<tr>
<td>Day 3</td>
<td>3 hr off twice a day (3 off, 9 on)</td>
</tr>
<tr>
<td>Day 4</td>
<td>4 hr off twice a day (4 off, 8 on)</td>
</tr>
<tr>
<td>Day 5 (not always needed)</td>
<td>6 hr off twice a day (6 off, 6 on)</td>
</tr>
</tbody>
</table>

- Alternatively, wean from CPAP by reducing CPAP pressure. This is more physiological, although it can increase the work of breathing if the pressure is too low
- wean pressures in steps of 1 cm H\(_2\)O every 12 hr. If no deterioration, reduce to 3 cm H\(_2\)O before stopping CPAP

Failure of weaning
- If nasal cannula oxygen >0.2 L/min required or marked respiratory distress develops, assess and put back onto CPAP, regardless of weaning regimen unless infant stable with chronic lung disease

2. ASSISTED CPAP (if available locally)
In this mode it is possible to give additional PIP above baseline CPAP pressure at a rate set by clinician (Biphasic) or as triggered (BiPhasic tr) by neonate

Equipment
- Infant Flow\textsuperscript{®} SiPAP, Viasys Respiratory Care Inc. A flow-driven machine, where pressure is directly related to flow used

Additional advantage over CPAP
- Improves thoracoabdominal synchrony over and above that of CPAP
- Better chest wall stabilisation
- Reduces upper airway resistance
- Reduces work of breathing
**Indications**

- Respiratory stabilisation in neonates born at ≤30 weeks
- Post-extubation in neonates born at <30 weeks
- Respiratory decompensation whilst on CPAP, with persistent tachypnoea, \( p_{\text{CO}_2} >8.3 \text{ kPa} \), \( \text{pH} <7.25 \), \( \text{FiO}_2 >0.4 \)
- Recurrent apnea and desaturations requiring manual breaths/IPPV
- CLD patients may be extubated onto biphasic CPAP from a higher MAP

**Modes on Infant Flow® SiPAP**

**CPAP and apnoea (AP)**

- CPAP with added advantage of apnoea monitoring via a sensor attached to abdomen
- Apnea alarm triggered when no breaths detected within set time-out period

**Biphasic**

- Bi-level pressure respiratory support
- Timed higher level (PIP) pressure rise above baseline CPAP, delivered intermittently at pressure and rate set by clinician
- Not synchronised with respiratory effort
- Can be set at variable rate (R) and with varying inspiratory times (Ti)
- Can be used with or without apnoea monitoring

**BiPhasic tr**

- Bi-level pressure respiratory support
- Higher level (PIP) pressure rise above baseline CPAP, at rate in synchrony with baby’s respiratory effort sensed through an abdominal sensor
- PIP and CPAP are set by clinician
- Inspiratory time (Ti) and back-up rate (Rb) can be varied, but back-up rate only comes into function if baby apnoeic or spontaneous breaths less than back-up rate
- Apnoea monitoring built into this model

**Available settings**

- NCPAP/low flow meter 0-15 L/min
- Pressure generated is directly related to flow (Figure 1) a flow of 8 L/min will generate a pressure of 5 cm H\(_2\)O
- PIP/high flow meter :additional flow 0-5 L/min
- \( \text{FiO}_2 \) : 21-100%
- Maximum CPAP pressure that can be delivered 11 cm H\(_2\)O (on CPAP and Biphasic mode)
- Maximum MAP that can be delivered 10 cm H\(_2\)O (on Biphasic tr mode)

<table>
<thead>
<tr>
<th></th>
<th>Default setting</th>
<th>Set ranges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apnoea alarm delay</td>
<td>20 sec</td>
<td>10, 15, 20, 25, 30 sec</td>
</tr>
<tr>
<td>Ti</td>
<td>0.3 sec</td>
<td>0.1-1.0 sec</td>
</tr>
<tr>
<td>R (unsynchronised PA)</td>
<td>30/min</td>
<td>1-120/min</td>
</tr>
<tr>
<td>Rb (trPA)</td>
<td>10/min</td>
<td>10-30/min</td>
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**Clinical use**

**BiPhasic**

- Set CPAP pressure at 5 cm H\(_2\)O or above based on clinical problem
- For neonates with mild RDS CPAP of 5-6 cm H\(_2\)O should be adequate
- For moderate to severe CLD use higher CPAP, may need to use up to 10 cm H\(_2\)O
- Set PIP at 3-4 cmH\(_2\)O higher over CPAP and begin with a rate of 30 breaths/min
- Keep Ti and apnoea alarm delay at default setting
- If CO\(_2\) retention, increase rate
- If necessary, increase PIP to give a maximum MAP 10 cm H\(_2\)O
- Avoid over-distension and keep PIP to minimum for optimum chest expansion

**Weaning**

- By pressure and rate
• If rate >30 bpm, wean to 30 bpm
• Reduce MAP, by reducing PIP by 1 cm H₂O every 12-24 hr
• When baby breathing above 30 bpm change to BiPhasic tr mode
• Once MAP down to 5-6 cm H₂O change to CPAP

**BiPhasic tr**
• In spontaneously breathing neonates it is advisable to use this mode as each breath is synchronised with the machine and each breath of baby is supported
• Set CPAP and PIP pressure as indicated in BiPhasic mode
• Keep Ti and apnoea alarm delay at default setting
• Set back-up rate at 10 bpm
• Maximum MAP delivered at this mode might be higher, up to 10 cm H₂O depending on baby's vigour. Reduce set PIP/MAP to avoid over-distension in these cases

**Weaning**
• By pressure only
• Reduce MAP, by reducing PIP by 1 cm H₂O every 12-24 hr
• Once MAP down to 5-6 cm H₂O change to CPAP
• If at any point during weaning, baby develops recurrent apnoea requiring manual breaths/further IPPV, assess baby and switch to BiPhasic mode at rate 30 bpm or higher to ensure adequate support
• Once baby re-establishes good spontaneous breathing change back to BiPhasic tr mode

3. **BUBBLE CPAP** (if available locally)
This is an alternative method of CPAP that may reduce work of breathing through facilitated diffusion

**Equipment**
• Fisher & Paykel bubble CPAP system:
  • delivery system
    - humidifier chamber
    - pressure manifold
    - heated circuit
    - CPAP generator
  • patient interface:
    - nasal tubing
    - nasal prongs (9 sizes)
    - infant bonnet (4 sizes)
    - chin strap

**Procedure**
• Connect bubble CPAP system to patient as per manufacturer’s instructions
• Ensure appropriate size nasal prongs used
• Bubble CPAP nasal prongs are designed not to rest on nasal septum to prevent septal damage. Ensure prongs are not resting on the philtrum nor twisted to cause lateral pressure on septum, and allow a small gap between septum and prongs
• Commence at pressures of 5 cm H₂O. Follow Pressure range in 1. STANDARD CPAP

**Bubble CPAP failure**
• See CPAP failure in 1. STANDARD CPAP

**Before inferring bubble CPAP failure**
• Ensure baby has been receiving bubble CPAP appropriately by checking for continuous bubbling in CPAP generator, lack of bubbling can result from pressure leaks in the circuit or baby