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In addition, all forms, instructions, checklists, guidelines, and examples are intended as resources to be used and adapted to meet national and local health care settings’ needs and requirements.
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This series has been designed with the intent of supporting the clinical use of technologies in newborn care units.

Newborn Essential Solutions and Technologies—Education (NEST-ED) Clinical Modules provide educational support for each of the technologies included in the NEST360 bundle for newborn care. These materials are intended to strengthen locally developed neonatal and technical trainings in pre- and in-service settings. Of note, these materials are not intended to be comprehensive clinical guidelines or targeted towards intensive care of the newborn. They are to be used to facilitate the implementation of comprehensive newborn care, including bubble CPAP, in a resource limited setting.

The NEST-ED Clinical Modules were developed through a combination of international standard review, international expert feedback, and multinational NEST360 expert consensus opinion. NEST-ED Modules form the backbone of all lectures, power points, job aids, and other supportive education materials supplied by NEST360.

To view the full series, visit www.nest360.org/resources
## ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ABC</td>
<td>Airway, Breathing, Circulation</td>
</tr>
<tr>
<td>bCPAP</td>
<td>Bubble continuous positive airway pressure</td>
</tr>
<tr>
<td>dL</td>
<td>Decilitre</td>
</tr>
<tr>
<td>FiO₂</td>
<td>Increased Fractional Concentration of Oxygen</td>
</tr>
<tr>
<td>Fr</td>
<td>French size</td>
</tr>
<tr>
<td>HAI</td>
<td>Hospital acquired infections</td>
</tr>
<tr>
<td>HCWs</td>
<td>Healthcare workers</td>
</tr>
<tr>
<td>HFNC</td>
<td>High flow nasal cannula</td>
</tr>
<tr>
<td>IV</td>
<td>Intravenous</td>
</tr>
<tr>
<td>KMC</td>
<td>Kangaroo mother care</td>
</tr>
<tr>
<td>LBW</td>
<td>Low birth weight</td>
</tr>
<tr>
<td>LCD</td>
<td>Liquid crystal display</td>
</tr>
<tr>
<td>LED</td>
<td>Light emitting diode</td>
</tr>
<tr>
<td>mm Hg</td>
<td>Millimeters of mercury</td>
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<tr>
<td>NEST360</td>
<td>Newborn Essential Solutions and Technologies</td>
</tr>
<tr>
<td>NEST-ED</td>
<td>Newborn Essential Solutions and Technologies-Education</td>
</tr>
<tr>
<td>NGT</td>
<td>Nasogastric tube</td>
</tr>
<tr>
<td>nm</td>
<td>Nanometer</td>
</tr>
<tr>
<td>O₂</td>
<td>Oxygen</td>
</tr>
<tr>
<td>OGT</td>
<td>Orogastric tube</td>
</tr>
<tr>
<td>ppm</td>
<td>Parts per million</td>
</tr>
<tr>
<td>ROP</td>
<td>Retinopathy of Prematurity</td>
</tr>
<tr>
<td>SpO₂</td>
<td>Peripheral blood oxygen saturation</td>
</tr>
<tr>
<td>UPS</td>
<td>Uninterruptible power supply</td>
</tr>
<tr>
<td>WASH</td>
<td>Water, sanitation and hygiene</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organization</td>
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<tr>
<td>wks</td>
<td>Weeks</td>
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## NOMENCLATURE

<table>
<thead>
<tr>
<th>Item</th>
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<tbody>
<tr>
<td>bCPAP prongs</td>
<td>bCPAP patient interface</td>
</tr>
<tr>
<td>Cot</td>
<td>Bassinet, infant crib</td>
</tr>
<tr>
<td>Christmas tree nozzle</td>
<td>Barbed oxygen fitting, nipple and nut adapter</td>
</tr>
<tr>
<td>Flow splitter</td>
<td>Oxygen splitter, flow meter stand</td>
</tr>
<tr>
<td>Glucometer</td>
<td>Glucose meter</td>
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<tr>
<td>Hospital Acquired Infection</td>
<td>Iatrogenic infection, nosocomial infection</td>
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<tr>
<td>Nasal prongs</td>
<td>Oxygen catheter, oxygen cannula, oxygen prongs</td>
</tr>
<tr>
<td>Positive Pressure</td>
<td>Positive end expiratory pressure, positive airway pressure</td>
</tr>
<tr>
<td>Radiant warmer</td>
<td>Resuscitaire, resuscitation table</td>
</tr>
<tr>
<td>Suction pump</td>
<td>Suction machine</td>
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Introduction

This NEST-ED Clinical Module has been prepared to help healthcare staff & students understand when & how to use bubble CPAP in newborn care. This is one module in a series of NEST-ED Clinical and Technical modules available that may be used by teaching institutions to supplement current newborn care curricula or by hospitals, clinical departments, and individuals to update their knowledge and to better facilitate the effective and safe use of newborn care equipment.

Whilst reading this series on a digital device, download and open the document in Adobe Acrobat, on the toolbar click View, Navigation Panes, and then click Bookmarks. Use the Bookmarks pane to navigate between sections of the document:

Every module has a similar structure with sections and subsections. The sections have similar headings and subheadings to make it easy for the user to navigate them. However, words may have different meanings for the various cadres of staff reading them and so to reduce misinterpretation, the heading titles are explained below.

An exception to this structure is the Infection Prevention & Control: General Infection Prevention module. This module describes general infection prevention measures in relation to the use of equipment in the ward. There are also sections on reprocessing of single use items and a useful table of suitable disinfectants.

**CLINICAL PROBLEM**

This describes the situations in which a piece of equipment may be clinically useful. It does not include all the clinical background in making that decision, as this should be covered in country-specific neonatal care protocols & clinical training materials.

**ASSESSMENT**

This section explains how a piece of equipment works, as well as how it may be useful in certain patient care settings (e.g., why an overhead radiant heater is useful for short term warming in the labour ward while resuscitating a newborn).

**MANAGEMENT**

Step by step preparation for setting up, checking, and using the equipment is described. This is followed by explanations of how to remove the equipment from a baby when it is no longer needed, how to clean it, and how to store it safely until further need.

**INFECTION PREVENTION**

In this section infection prevention measures are described for the equipment when in use, followed by instructions on how to disinfect the equipment both during and after use.
The complications described in this section are those relating to the use of the equipment and do not include all clinical complications that may arise from underlying medical problems. These are beyond the scope of the modules and should be covered in clinical training materials.

Advice is given on where to place equipment for use, how to safely handle such devices and their consumables, and how to keep them functioning well by using preventive maintenance measures.

This section provides helpful advice on what to check if equipment is malfunctioning on the ward. It is intended to help healthcare staff deal with minor technical difficulties for which there are simple remedies. Detailed machine maintenance is beyond the scope of these modules and is covered in the technical modules that accompany these clinical ones.

A few questions are attached based on module content. These may be used, for example, during mentoring visits or to emphasise some of the points raised in teaching with the module.

References and alert boxes are included within each module to provide clarity on areas where recommendations are governed by published standards, evidence, and/or expert opinion. This is included for the dual purpose of facilitating (1) feedback and continuous improvement of NEST-ED Education Modules and (2) implementer review of content for incorporation in local trainings.

QUERY ALERT BOXES appear where there may be controversy or disagreement. In these cases, alert boxes provide background to the recommendations that are made in the body of the document. Relevant documents are cited and brief explanation of reasoning for current module content provided.

RECOMMENDATION ALERT BOXES appear where there are recommendations based largely on expert opinion or consensus, or to emphasize an important element of care. Relevant documents are cited and brief explanation of reasoning for current module content provided.
Respiratory Support

Bubble CPAP
1 Clinical Problem

Bubble CPAP (bCPAP) devices provide both positive pressure & increased fractional concentration of oxygen (FiO₂) to newborns with respiratory distress. Bubble CPAP (bCPAP) is particularly useful for premature babies with respiratory distress syndrome. (1.1)

Very premature babies (<1.5kg and <32 weeks) benefit from early bCPAP. (Alert 1.1) Reference can be made to the TRY algorithm (see below). Depending on your facility and your national policy the lowest weight at which to commence bCPAP may differ. bCPAP should only be used when essential newborn care is in place, the equipment is functioning, oxygen is available, staff are adequately trained in bCPAP, and close monitoring can be assured.
**ALERT 1.1: When do you initiate bCPAP vs low flow oxygen?**

Regarding the initiation of bCPAP versus low flow oxygen on the day of birth, protocol developers should consider the following functions and evidence. bCPAP functions to treat respiratory distress by improving both ventilation (controlled provision of continuous inspiratory pressure) and oxygenation [controlled provision of increased percentage of oxygen - term the fraction of inspired oxygen (FiO₂)]. The positive pressure from bCPAP prevents lung tissue (alveolae) from collapsing on expiration thus improving ventilation, reducing the work of breathing and preventing potentially irreversible lung damage. Additionally, bCPAP has been shown to promote production of endogenous surfactant, improve apnoea of prematurity and dramatically decrease progression to mechanical ventilation, or death, in both high income and low income settings.

Thus, early bCPAP for preterm & small newborns, especially in settings where mechanical ventilation and surfactant are unavailable, is critical to prevent death. At a minimum, evidence points to preferential early initiation of bCPAP, rather than low flow oxygen, in preterm newborns under 1.5kg with any respiratory distress on the day of birth.

Bubble CPAP may also be used to treat neonatal patients with increased work of breathing, designated by nasal flaring, grunting, head nodding, severe recession, RR >60, or an oxygen requirement of 0.5 to 1 L/min with peripheral blood saturations of <90%, in premature or term infants. (Alert 1.2)

Increased work of breathing may be caused by:
- Neonatal pneumonia
- Severe transient tachypnoea of the newborn
- Persistent pulmonary hypertension of the newborn
- Apnoea of prematurity
- Meconium aspiration syndrome
- Neonatal sepsis with severe respiratory distress

The TRY algorithm may be used by a nurse or clinician to decide who would benefit from bCPAP and, if necessary, whom to prioritise. The TRY algorithm signs and symptoms on which to act are straightforward and easily carried out. Premature babies benefit most from CPAP and are given priority. Babies with severe asphyxia leading to poor tone will not benefit. If CPAP machines are few in number, it is important to provide CPAP to those who will benefit most. There are always exceptions and in tertiary care units a paediatrician may decide to give CPAP to other infants. Deciding when to start CPAP for a premature baby may differ between national guidelines.

Contraindications to bCPAP include:
- Significant bleeding from mouth and nose
- Anatomical abnormalities of mouth and nose e.g., choanal atresia, cleft lip and palate
- Other obvious malformations incompatible with life
- Presence of a pneumothorax

Severely asphyxiated babies (with severe hypoxic ischaemic encephalopathy) do not benefit from bCPAP.
Alert 1.2 bCPAP & low flow oxygen context

Scale & delivery of neonatal care is critical. However, epidemiological data has shown that rapid scale up of neonatal care without sufficient attention to safety has long term negative consequences for neonatal morbidity\(^\text{10}\) and is likely a contributor to the epidemic of preventable blindness due to retinopathy of prematurity (ROP) in these settings.\(^\text{17}\)

Supplemental oxygen is life-saving. However, when given in supra-optimal doses, it has also been associated with ROP,\(^\text{18}\) bronchopulmonary dysplasia,\(^\text{19}\) periventricular leukomalacia and prolonged ventilation.\(^\text{20}\) When using any form of oxygen therapy, it is important to closely monitor blood oxygen saturation (SpO\(_2\)) levels in order to balance risks and benefits of supplemental oxygen. Exact blood oxygen saturation targets for premature newborns remain an area of controversy. However, most authorities agree that SpO\(_2\) between 90-95% is reasonable to minimise complications associated with low and high oxygen levels.\(^\text{21-24}\)

When choosing between low flow oxygen and bCPAP it is important to keep the following physiological considerations in mind. Newborns under 2.5kg receiving low flow oxygen exceeding 0.5 L/min are administered 40-100% effective FiO\(_2\),\(^\text{25-28}\) which may increase morbidity. Delivery of low flow oxygen in preterm newborns under 1.5kg has the added complexity that positive pressure can be delivered even at flows as low as 1-2.5 L/min.\(^\text{29,30}\) Unfortunately, as discussed above, at these rates of low-flow oxygen, preterm newborns would be exposed to elevated levels of effective FiO\(_2\) which data show are likely to increase their morbidity.

In light of the above evidence and expert opinion, the recommendation was made by our consortium to consider bCPAP in appropriate settings when low flow oxygen greater than 0.5 - 1 L/min is required to maintain saturations >90%. Of note, this recommendation is in line with the WHO recommendation that a standard flow rate for neonates is 0.5 – 1L/min in WHO Oxygen Therapy for Children;\(^\text{31}\) however, it is unaligned with the suggestion to consider 4L/min of oxygen as the transition threshold from nasal prongs to bCPAP.

bCPAP outside the neonatal period is not addressed by NEST360 materials.
TRY BCPAP ALGORITHM

ASSESSING WHICH PATIENT TO PUT ON bCPAP
Always perform ABC assessment and resuscitation as needed BEFORE beginning TRY bCPAP

T
TONE is good

R
RESPIRATORY DISTRESS:
O₂ saturations less than 90% on O₂ 1 L/min

Y
YES for HR greater than 100 bpm

NO bCPAP
Put on O₂ 1 L/min if saturation is less than 90% in room air

Baby is breathing
HR greater than 100 bpm
Weight more than 1 kg

Tone is POOR
Baby is floppy

WEIGHT IS BETWEEN 1-1.5 kg
PREMATURE less than 30 wks
EARLY bCPAP

WEIGHT IS MORE THAN 1.5 kg
RR greater than 60 breaths per minute
O₂ Saturations less than 90% in room air
Signs of increased work of breathing
START bCPAP
2 Assessment

Respiratory distress can cause hypoxia contributing to both morbidity and mortality. Bubble CPAP devices (2.1) use a pump to provide a blend of air and oxygen at a continuous positive pressure. This pressure keeps airway spaces open and increases alveolar recruitment throughout respiration in a spontaneously breathing infant, which improves oxygenation and reduces work of breathing.

Traditional bCPAP devices are made up of the following components:

- **Pump:** pumps in air mixed with oxygen from an oxygen source.
- **Inspiratory tube:** connects the blended air and oxygen flow source to the patient.
- **Expiratory tube:** connects the patient to the pressure regulator.
- **Pressure regulator:** a water reservoir placed at the end of the expiratory circuit that provides pressure using water level.

bCPAP devices range in complexity from vitals measured (e.g., saturations/respiratory rates measured on the device) to outputs (e.g., humidified pressure vs pure pressure). (Alert 2.1)

Pressures used in bCPAP devices range from 5 to 10 cm of water. As bCPAP delivers a blend of air and oxygen, staff should also carefully monitor patients for oxygen saturation using a pulse oximeter. Neonatal patients should reach oxygen saturations of 90 – 95% by 15 minutes after birth. (Alert 2.2)
ALERT 2.1: Use of humidification in bCPAP

Some bCPAP units use heated and humidified gas in the circuit although the exact benefits of humidification in non-invasive ventilation (i.e., bCPAP) in terms of survival, complications from therapy & morbidity are not well established. For a more thorough review of theoretical risk/benefits of heated humidified oxygen in bCPAP, see Appendix 1.

Potential benefits of heating and humidification could include:

- Increased comfort and adherence.
- Decreased upper airway mucosal injury.
- Decreased convective heat losses which may lead to hypothermia & challenging weight gain in infants.
- Decreased lung inflammation from mucus plugs which has unknown impact on morbidity & mortality of very low birthweight infants.

Potential drawbacks to heated humidification include:

- Hospital-acquired infection, especially in settings where clean water may not be readily available and humidifiers, which are typically meant for one-time use, are being cleaned and re-used between patients.32
- High financial cost of adding heated humidified gas.33
- High human resource cost in terms of repair and preparation of non-invasive ventilation units which may limit not only their use, but availability of this life saving technology within our setting.33

In summary, based mostly on expert opinion, it is likely that heated and humidified air is most important for the smallest newborns <1-1.25kg although this has never been explicitly studied. There is evidence from Malawi that unheated un-humidified bCPAP can be used successfully to decrease mortality of infants without excessive reports of upper airway complications, but physiological implications in terms of morbidity and mortality (hypothermia & weight gain) were not explicitly studied. Of note, survival of infants >1.5kg on un-heated un-humidified air bCPAP in this study33 were similar to survival of infants >1.5kg in Rwanda on heated and humidified bCPAP.34

At this time, based on expert opinion and available literature, it does not appear that the benefits of humidification outweigh the potential risks/drawbacks for infants >1kg. Further study of the degree of humidity provided by compressed air in various settings as well as implications of humidification in low resource settings on iatrogenic infections, morbidity, and mortality of neonates is needed.

ALERT 2.2: SpO₂ & Safe Oxygen Delivery

When making this recommendation the following resources were considered:

1. According to the Textbook of Neonatal Resuscitation (NRP), 7th Ed., “After birth, the oxygen saturation gradually increases above 90%. However, even healthy term newborns may take 10 minutes or longer to reach this saturation.” (p. 77) 36

2. Target peripheral oxygen concentrations (SpO₂) for newborns vary depending on age and clinical condition. However, most authorities agree that saturations between 90-95% minimises the complications associated with both low and high oxygen levels including death, neurodevelopmental impairment and ROP. 21-24
3 Management

Management of bCPAP covers how to use the bCPAP device including set up for a patient, patient preparation & commencement, care whilst on the device & removal of the patient from the device.

SETTING UP FOR A PATIENT

1 Collect: (3.1)
   - bCPAP machine
   - Power cable
   - Inspiratory tubing
   - Expiratory tubing
   - CPAP prongs
   - Connectors
   - Oxygen tubing
   - Oxygen source

2 Position the bCPAP device at a secure location near the patient being considered for bCPAP treatment. Plug the power cable into the back of the machine (3.2) and plug into a socket or extension.
3. Pull the bottle strap gently away from the bottle and remove the bottle. (3.3) Unscrew the lid and fill with clean water to desired initial settings. (3.4) Most patients will start with pressure levels of 6 cm of water. Rescrew the bottle lid to the bottle and place back in bottle holder.

4. Connect the inspiratory tubing to the Patient Port (indicated by the baby icon) (3.5) and the expiratory tubing to the Bottle Port. (3.6)

5. Connect the CPAP prongs between the inspiratory and expiratory tubing. (3.7)

6. Turn on the bCPAP device. (3.8)
7. Open the oxygen flowmeter. Using oxygen tubing, connect the oxygen source to the bCPAP device. (3.9)

8. Test the bubbling of the bCPAP device by occluding the CPAP prongs with your fingers. (3.10) If the water within the water bottle bubbles, the bCPAP device is ready for use.
PREPARING A PATIENT

1. Place patient on oxygen and keep the baby warm whilst preparing for bCPAP.
2. Always explain the purpose, risks, and benefits of a procedure to guardians BEFORE performing the procedure.
3. Follow handwashing protocol.
4. Collect:
   - Hat or length of stockinette (if hat is not available)
   - Orogastric tube (OGT)
   - Gloves
   - Syringe
   - Tape
   - Suction catheter
   - Correctly sized bCPAP prongs
5. If a hat is not available, make a hat from a length of stockinette. (3.11)

6. Wash hands and put on gloves. Using suctioning guidelines, suction the patient’s nose and mouth using the suction catheter if clinically indicated. (3.12)
Insert an OGT: (Alert 3.1)

a. Place the patient's head in a neutral position, measure from the middle of the mouth to the ear and then to halfway between the xiphisternum and umbilicus. Mark this distance with a small amount of tape.

b. Gently insert the OGT in the mouth to this length.

c. Tape the OGT to the chin to keep in place. Use appropriate tape for delicate newborn skin.

d. Check placement of the OGT.26
   - Using a syringe aspirate gastric contents. Test with litmus paper. The litmus paper's colour change should reflect an acidic pH (<=6); if it does not, the OGT is incorrectly placed and should be re-sited. NOTE: Litmus paper is manufactured in different colours. Acidic pH may be indicated by different colour changes depending on manufacturer.
   - If no gastric contents are aspirated, perform a whoosh test: push 2ml of air down the OGT whilst listening over the abdomen with a stethoscope. If no gurgling sound is heard the OGT is incorrectly placed and should be re-sited.
   - If no gastric contents are aspirated and a whoosh test is not viable, an alternative method is to place the OGT end into water. If continuous bubbling occurs, the OGT is incorrectly placed and should be re-sited.

Select bCPAP prong size from 000 to 5 based on nostril size. bCPAP prongs should completely fill the patient's nostrils. If prongs do not fill the nostril completely, the pressure delivered to the patient will be decreased. If nostrils turn a white colour the prongs are too tight and should be exchanged for the next size down.
STARTING A PATIENT

1. Collect: (3.13)
   - Appropriately sized bCPAP prongs
   - Hat
   - 2-ml syringe filled with normal saline
   - Hat clips OR
   - 2 rubber bands & 4 safety pins

2. Turn on the bCPAP device and connect oxygen source. Place hat on patient.

3. Determine initial settings for the patient. Most patients will start with a pressure level of 6 cm water, total flow of 6 L/min and oxygen concentration (FiO₂) of 50%. Determine oxygen flow using FiO₂ and total flow as shown on the oxygen blending table printed on top of device. (3.14)

4. Set total flow. Set oxygen flow on both oxygen source and bCPAP oxygen flowmeter.

5. Connect correctly sized bCPAP prongs to the inspiratory and expiratory tubing. Retest the bubbling by pinching the bCPAP prongs shut.

6. If the water within the pressure regulating bottle bubbles:
   - Using syringe filled with saline, place a drop of saline within each nostril.
   - Gently insert the prongs into the nostrils with the writing on the prongs facing towards the caregiver.
   - bCPAP prongs should be inserted until the line on the bCPAP prongs is just visible. This will leave 1 mm of space between the prongs and the nasal septum to aid nasal patency. (3.15)

7. Secure inspiratory and expiratory tubing to the patient using hat clips. (3.16) If hat clips are unavailable, secure using rubber bands & safety pins:
   - Insert two safety pins on each side of the head in the brim of the hat. Pins should open away from the baby’s face and should go only through the folded brim of the hat. Pins should never touch the patient’s skin.
   - Hold the inspiratory tubing in place between the two safety pins. Wrap the rubber bands around the safety pins on either side of the tubing to secure. Repeat for the expiratory tubing on the other side of the patient’s face. (3.17)
- Recheck that the prongs are still within the nose and inserted to the correct distance from the nasal septum.
- Sometimes a small folded cloth placed under the baby’s shoulders prevents the neck from bending and improves air/oxygen flow.

8 Check that the water within the pressure regulating bottle bubbles. If it does not bubble, check that the prongs completely fill the patient’s nostrils. If they do not, replace with appropriately sized prongs.

9 Monitor the patient 15 minutes after initiating bCPAP treatment and then 4 hourly for:
   - Vital signs, including respiratory rate, heart rate, oxygen saturation and temperature
   - Work of breathing
   - Nasal blockages
   - Abdominal distension

10 Act in accordance to clinical findings.
CARING FOR A PATIENT

Monitoring the patient should be completed 4 hourly, but may be required more frequently depending on clinical condition. Monitoring should include:

- Vital signs, including respiratory rate, heart rate, oxygen saturation, and temperature
- Work of breathing
- Nasal blockages
- Abdominal distension
- Nasal septum trauma or breakdown

At every monitoring point:

1. Provide a drop of saline to each nostril. (**3.18**)  
2. Check prongs, tubing & hat:  
   - Prongs should not be against nasal septum and check for skin compromise  
   - Tubing should not be kinked or misplaced  
   - Hat should not be loose; if it is loose, replace with new hat

3. Check water level: if water level is below decided treatment level, add water into bottle cap hole using a syringe or OG tube. (**3.19**) Water should be changed daily.

Prior to increasing bCPAP always ensure the bCPAP device is functioning well and all parts are in place. One mnemonic to help with this is **DOPE**:

- **D**: Displacement of prongs  
- **O**: Obstruction of prongs or tubing  
- **P**: Patient problem (e.g., pneumothorax)  
- **E**: Equipment failure (e.g., power cut, tubing leak, see complications section)

Increases in treatment are made in accordance to the **Increasing bCPAP Treatment** algorithm.
**INCREASING bCPAP**

**INCREASING bCPAP TREATMENT**

Increase by pressure and fractional concentration of oxygen ($\text{FiO}_2$)

- **bCPAP water level:** 6 cm
- **Oxygen:** 3 L/min
- **Blended flow:** 6 L/min
- **$\text{FiO}_2$:** 50%

---

**Criteria for increasing bCPAP treatment:**

The bCPAP device is functioning well, but any one of the following is present:

1. **Respiratory rate** greater than 60 bpm
2. **$\text{O}_2$ Saturation** less than 90%
3. Persistent increased work of breathing

---

**Always check connections before increasing treatment**

- Is the water bubbling? Does the baby need suctioning?
- Reassess the baby after 15 min after any setting change

---

- **Yes**
  - **O$_2$ saturations greater than 90%?**
  - **No**
    - **Increase $\text{FiO}_2$ to 70%**
      - **Oxygen:** +1 L/min
      - **After 4 hours:**
        - **O$_2$ saturations greater than 90%?**
          - **Yes**
            - Substantial indrawings or work of breathing?
              - **No**
                - **BABY IS RESPONDING TO TREATMENT. Continue management.**
              - **Yes**
                - **Increase pressure & maintain $\text{FiO}_2$**
                  - **$\text{FiO}_2$:** 70%
                  - **Oxygen:** 5 L/min
                  - **bCPAP water level:** 7 cm
                  - **Blended flow:** 7 L/min
        - **No**
          - **Increase $\text{FiO}_2$ & maintain pressure**
            - **$\text{FiO}_2$:** 80%
            - **Oxygen:** 4.5 L/min
            - **bCPAP water level:** 8 cm
            - **Blended flow:** 6 L/min
          - **O$_2$ saturations greater than 90%?**
            - **No**
              - **Maintain Total Flow & increase:**
                - **Oxygen:** +0.5 L/min
                - **bCPAP water level:** +1 cm
                - **$\text{FiO}_2$:** +10%
                - **Reassess for complications or alternative diagnosis.**
              - **CALL FOR ASSISTANCE!**
                - bCPAP water pressure should not be above 8 cm
WEANING A PATIENT FROM bCPAP TREATMENT

Select starting point by bCPAP FiO₂ settings

Does patient meet weaning criteria?

No

KEEP ON bCPAP

Yes

Patient continues to meet weaning criteria

bCPAP Settings: more than 50% FiO₂

Maintain bCPAP water level Gradually reduce FiO₂ by 10% 4 hrly until FiO₂ reaches 50%

bCPAP Settings: less than or 50% FiO₂

Alternately reduce FiO₂ by 10% and water level by 1 cm 4 hrly until FiO₂ reaches 20% and water level reaches 5 cm

Patient stable for 4 hours

FiO₂: 21% (Air) Water level: 5 cm

Remove from bCPAP and leave on room air

Reassess patient after 15 min, 1, 4 and 8 hours

If a water level of 5 cm or 20% FiO₂ is reached while alternating Maintain water level or FiO₂ and continue to decrease other setting

Stability Criteria for weaning bCPAP

Patient is clinically stable as below:

1. Respiratory rate less than 60 bpm
2. SpO₂ greater than 90%
3. No significant signs of increased work of breathing
4. No other signs of respiratory distress

Reassess the baby 15 min after any setting change

Blended Flow

<table>
<thead>
<tr>
<th>FiO₂</th>
<th>O₂ flow rate (L/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>90%</td>
<td>4.5, 5, 6, 7, 7.5, 8.5</td>
</tr>
<tr>
<td>80%</td>
<td>4, 4.5, 5.5, 6, 7, 7.5</td>
</tr>
<tr>
<td>70%</td>
<td>3.5, 4, 5, 5.5, 6</td>
</tr>
<tr>
<td>60%</td>
<td>3, 3.5, 4.5, 5, 5.5, 6</td>
</tr>
</tbody>
</table>

Blended Flow

<table>
<thead>
<tr>
<th>FiO₂</th>
<th>O₂ flow rate (L/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50%</td>
<td>2.5, 3, 3.5, 4, 4.5, 5</td>
</tr>
<tr>
<td>40%</td>
<td>2, 2.5, 2.5, 3, 3.5, 3.5</td>
</tr>
<tr>
<td>30%</td>
<td>1, 1.5, 2, 2, 2.5</td>
</tr>
<tr>
<td>20%</td>
<td>0, 0, 0, 0, 0</td>
</tr>
</tbody>
</table>

If patient meets criteria for bCPAP again at any point, restart bCPAP and discuss patient with seniors.
4 Infection Prevention

Infection prevention, especially when using humidification or re-processing respiratory circuits intended for single use, is CRITICAL to preventing equipment related infections in newborns. If devices and equipment are not disinfected or re-processed promptly or adequately between patients, they may pose a significant infection risk.

**GENERAL INFECTION**

1. Clean hands with soap and water or 70% alcohol before and after placing a patient on bCPAP or handling any tubing that will be used on a patient.

2. Ensure that all patient-related tubing (including prongs, inspiratory, and expiratory tubing) is new or has been cleaned thoroughly and dried as per re-use guidelines. **(Alert 4.1)** Any patient-related tubing must be cleaned before it is used to place another patient on bCPAP. Nasal prongs are especially difficult to clean thoroughly. Tubing should be hung to dry after disinfection and should not touch the floor or other unsanitary surfaces whilst drying. Any item falling on the floor is contaminated and must be cleaned thoroughly again.

3. All patient-related consumables should be stored in a clean, dry location. Tubing should be stored in loose rolls, preventing sharp bends or kinks which will decrease the lifetime of the tubing.

**ALERT 4.1: Re-processing single-use devices**

Respiratory circuits and humidifiers associated with bCPAP are generally intended as single use devices. However, in areas with limited resources or challenging supply chains this equipment is often re-used. When re-processing single use devices it is extremely important that the process is not delayed following completion of use. There should be a detailed standard of practice as well as oversight processes for ensuring timely and high-quality re-processing. If equipment is not re-processed promptly or adequately between patients it poses a significant infection risk. Please refer to the Reference Manual for Health Care Facilities with Limited Resources Infection Prevention and Control Module 6 for more detailed guidance on the re-processing of single use devices.

**DISINFECTION AFTER USE**

1. Turn off bCPAP and dispose of water within pressure regulating water bottle.

2. Dispose of hat and follow protocols for cleaning tubing if reusing prongs, inspiratory and expiratory tubing. If patient consumables are not cleaned thoroughly before using, infection can be transmitted. Care should be taken particularly for consumables that are marked as single-use but are practically reused.

3. Clean the outside of the bCPAP device using a swab soaked in alcohol or diluted chlorine. Total and oxygen flowmeter regulator controls should be disinfected after each use using a cotton swab or gauze soaked in 70% alcohol.
5 Complications

Introduction of equipment in newborn care units poses clinical and device complications for patients. Awareness of potential complications is critical to maximise patient safety.

**CLINICAL COMPLICATIONS**

- **Nasal blockage**: the bCPAP prongs and nostrils can become blocked with mucus which may result in increased respiratory distress and impaired oxygen delivery resulting in hypoxia.
- **Necrotic nasal septum**: incorrectly sized or applied bCPAP prongs may result in pressure on the nasal septum with resultant necrosis (tissue breakdown).
- **Gastric distension**: delivery of continuous airway pressure can cause gastric distension and potential feed intolerance. The OGT should be closed for 30-60 min after feeding but otherwise the OGT should be kept open on free drainage as this may relieve distension.
- **Pneumothorax**: delivery of bCPAP occasionally causes a pneumothorax. If a patient suddenly deteriorates whilst on bCPAP with increased respiratory distress and worsening hypoxia assess for a pneumothorax.
- **Decreased cardiac output**: with excessive bCPAP levels, venous return may be reduced resulting in decreased cardiac output.

**DEVICE COMPLICATIONS**

- **Pressure leakages**: if the water in the bottle is not bubbling, it is likely that the patient is not getting therapeutic pressures. This may be due to the patient’s mouth being open or bCPAP prongs not fully fitting the patient’s nostrils. It could also be caused by kinking of the tube or a loose tube connection. Bubble CPAP: Troubleshooting & Repair | If the water in the bottle is not bubbling to identify and manage potential causes for no bubbling.
- **Power failure**: bCPAP should ideally always be utilising outlets that have a source of back-up power. If the power supply fails and patients are NOT on outlets with back-up power they should be moved to outlets where back up power is available. If no back up power is available the baby should receive oxygen from an oxygen cylinder until they can be safely returned to bCPAP.
6 Care & Maintenance

Users are responsible for basic first-line care and maintenance to ensure equipment lasts to their potential lifetime.

**POWER SOURCE**

Mains power.

**WARD LOCATION**

The bubble CPAP device should be secured in an easily accessible and visible location near an oxygen source where nursing staff can regulate flows and manage patients easily, but where it is not at risk of falling. All consumables required to place a patient on bCPAP should be near the device and readily available to start treatment. bCPAP devices vibrate during use; ensure that the vibration is not causing excess sound (e.g., if placed on a table with metal instruments that will vibrate with the bCPAP device).

**USER PREVENTIVE**

Minimal preventive maintenance is required for bCPAP devices. The bCPAP device should be turned on weekly to a total flow of 10 L/min and allowed to run while connected to an oxygen source at 2 L/min for at least 15 minutes. This is important to ensure device functioning and minimise infection risk within internal respiratory circuits.

7 Troubleshooting & Repair

Although users are not responsible for repairing their devices, there are steps that may be taken to troubleshoot first-line errors that may occur before contacting maintenance or engineering support.

<table>
<thead>
<tr>
<th>1</th>
<th>The device does not turn on</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check that the power cable is securely attached (7.1) and connected to the socket.</td>
<td></td>
</tr>
<tr>
<td>Check that the power at the socket is turned on.</td>
<td></td>
</tr>
<tr>
<td>If the device still does not turn on, contact your maintenance department.</td>
<td></td>
</tr>
</tbody>
</table>
2 If the silver balls in the oxygen or total flowmeters are not going up

Tap the front of the flowmeter firmly with your knuckle or the handle of a screwdriver (or similar).

If the flowmeter silver balls still do not go up, contact your maintenance department to request cleaning of the flowmeter and to check that all internal tubing is still connected.

3 If the total flowmeter does not go up to 10L/min

Contact your maintenance department to request an internal filter change.

4 If the water in the bottle is not bubbling

Check that the bCPAP prongs fully fill the nostrils and that the patient’s mouth is not open. If the prongs do not fully fill the nostrils, replace the prongs with a larger size.

If the prongs are well-fitted, remove from the patient’s nose and occlude the prongs with your finger. If the water is still not bubbling check the seal at the patient port. If the seal is deteriorating or cracked (7.2), contact your maintenance department to replace or troubleshoot further.

7.1 Power cable should not be pulling out of power socket.

7.2 Deteriorating seal.
Assessment Questions

1. Label the image below.

2. What is the maximum water pressure that should be used with neonatal patients? 8 cm water.

3. Where should the initial oxygen flow be set for a bCPAP device? On the oxygen source and on the bCPAP Oxygen Flowmeter.
Appendix 1

Heated & Humidified Air in Non-Invasive Ventilation

When breathing, air is physiologically heated and humidified as it passes through our upper airways into the lungs. Artificial heating and humidification are essential in invasive ventilation (i.e., when using ventilators) which bypasses the upper airways. However, the risks and benefits of heating and humidifying air supplied through non-invasive ventilator techniques such as Highflow Nasal Cannula (HFNC) and bCPAP are not well established and currently there is not consensus about whether or not it is a necessary element of all non-invasive ventilation systems.36,39

Benefits of heated and humidified gas in non-invasive ventilation may include increased adherence and comfort.38 In neonates specifically, there is a physiological argument that removal of heated and humidified gas may lead to increased convective heat losses and therefore increased metabolic demand as well as increased insensible fluid losses. One needs to consider if these effects may or may not have significant effects on the infant's ability to maintain their temperature and grow adequately during the first weeks of life impacting mortality. In the long term, the effect of removing humidification on morbidity of infants (specifically in terms of development of bronchopulmonary dysplasia) is also unknown.30 Lastly, heated humidified bCPAP may lead to lower incidence of mucosal injury which, in one study, was linked to increased rates of sepsis in extremely low birthweight infants; however, early data from Malawi demonstrated few mucosal injuries when using un-heated un-humidified bCPAP.41

Risks of humidification include a theoretical risk of infection especially in settings where clean water may not be readily available and humidifiers, which are typically meant for one time use, are being cleaned and re-used between patients.32 In addition, humidification incurs a high financial cost as well as human resource costs in terms of repair and preparation of non-invasive ventilation units which may limit not only their use, but availability of this life saving technology within low resource settings.33

There is reason to believe that when supplying ambient air through the upper airway there is in fact, no need for heated humidification.38 This may be doubly true in low resource bCPAP units such as the Pumani which, rather than using compressed air sources (i.e., cylinders) are in fact driving flow through the circuit using compressed ambient air.42 It is worth noting that although some lower cost bCPAP models do offer passive humidification, expert opinion and experience suggests that perhaps the level of humidification achieved via this method is not significant (data unpublished). Of note, although the studies differ significantly, reported survival rates for infants >1.5kg in Rwanda on a heated and humidified bCPAP circuit34 were similar to those reported in Malawi on an un-heated, un-humidified circuit.12

In conclusion, despite recent WHO recommendations that bCPAP units should contain humidification,31 in light of primary data which shows (1) the unknown necessity, (2) the risks and benefits of heated and humidified gas in non-invasive ventilation, and (3) the life-saving implications bCPAP has for neonates, our consortium maintains there is a lack of evidence to resolve the question of humidification at this time. Further study of the degree of humidity provided by compressed air in various settings as well as implications of humidification in low resource settings on iatrogenic infections, morbidity and mortality of neonates is needed. It is important that when considering implementation of bCPAP, one considers not only physiological implications of this feature in the bCPAP units, but also how this feature impacts supply chain, human resource costs, financial costs, training, infection control, maintenance, and availability of units in country.
References


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