Guidelines for use of Bubble-CPAP concentrators

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Standard oxygen therapy, either using concentrators or cylinders, saves the lives of many children. Use CPAP if the child is failing standard oxygen therapy.

Indications for CPAP

- Severe respiratory distress despite oxygen therapy
- Severe hypoxaemia (SpO_2 <85%) despite high flow oxygen therapy

CPAP is usually effective for children with pneumonia and bronchioitis. If children have other comorbidities, such as anaemia, or pneumonia, or TB, or meningitis, these need to be treated also, or CPAP alone will not be useful.

Conditions for which CPAP is not usually useful or contraindicated

CPAP is contraindicated if a child has pneumothorax as it can make the air leak worse. In some conditions like staphylococcal pneumonia with pneumatocoeles on chest xray, CPAP can increase the risk of pneumothorax, so caution is needed.

CPAP will not be effective in an unconscious child who is not taking breaths of their own.

CPAP is not usually useful for children with congenital heart disease with pulmonary hypertension, or severe chronic lung disease with pulmonary hypertension.

Checklist if a child is hypoxaemic despite oxygen:

Before using CPAP in a child on oxygen you should check:

1. Check that oxygen is flowing (put the end of the tube under water in a beaker and watch for bubbles, or hold the end close to your hand to feel the air flow);
2. Check the oxygen tubing is not leaking;
3. Check the nasal prongs or nasal catheter are fitted correctly and not blocked; and
4. If the oxygen is being delivered from a concentrator, the concentration of oxygen delivered is adequate (> 85%) using an oxygen analyser.
5. Check for pleural effusion: listen with a stethoscope for breathing sounds on both sides of the chest; do a chest X-ray;
6. Check for pneumothorax: listen with a stethoscope for breathing sounds on both sides of the chest; do a chest X-ray;

7. Check for bronchospasm (e.g. severe asthma): listen with a stethoscope for wheeze;
8. Check for cyanotic heart disease or congestive heart failure;
9. Check if there is ventilatory failure: the child's respiratory effort is inadequate, or the child has slow or shallow breathing and is lethargic.
10. Increase oxygen through nasal prongs to maximum flow (4 L/min for infants and up to 8 L/min for older children)

If the child is still hypoxaemic or has severe respiratory distress then it is right to use CPAP

What is CPAP?

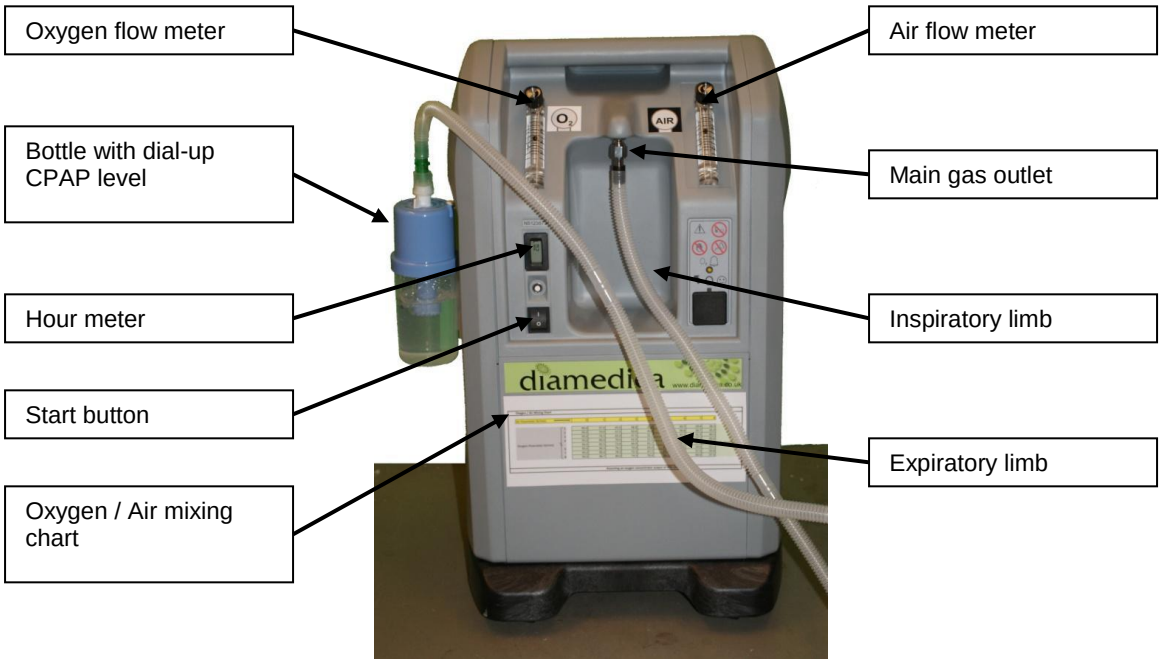
Continuous positive airway pressure (CPAP) consists of delivery of mild air pressure to keep the airways open. CPAP delivers positive end-expiratory pressure (PEEP) with a variable amount of oxygen to the airway of a spontaneously breathing patient to maintain lung volume during expiration. CPAP decreases atelectasis (alveolar and lung segmental collapse) and respiratory fatigue and improves oxygenation. It is indicated for infants with severe respiratory distress, hypoxaemia or apnoea despite receiving oxygen.

CPAP requires a source of continuous airflow (often an air compressor) and usually requires an oxygen blender connected to an oxygen source. A CPAP system is available in some hospitals but should be used only when it is reliable, when oxygen systems are in place, where staff are adequately trained and when close monitoring is assured.

Any bubble CPAP system has three main components:

1. Continuous oxygen and air flow into the circuit: The gas flow rate required to generate CPAP is usually 5–10 L/min. All children with severe pneumonia and many neonates weith RDS require supplemental oxygen. Therefore, the system requires an oxygen blender, which connects an oxygen source (cylinder or concentrator) to the continuous airflow to increase the FiO_2.
2. A nasal interface connecting the infant's airway with the circuit: short nasal prongs are generally used to deliver nasal CPAP. They must be carefully fitted to minimize leakage of air (otherwise, CPAP will not be achieved) and to reduce nasal trauma.
3. An expiratory limb with the distal end submerged in water to generate end-expiratory pressure; in bubble CPAP, the positive pressure is maintained by placing the far end of the expiratory tubing in water. The pressure is adjusted by altering the depth of the tube under the surface of the water.

A gas (oxygen) flow rate of 5–10 L/min is required for older children with pneumonia, while 3–4 L/min may be sufficient to generate CPAP in small neonates. In premature neonates < 32 weeks' gestation, pure oxygen is **not** safe as a high concentration can cause retinopathy of prematurity.



The CPAP concentrator

Oxygen concentrators are machines that extract nitrogen from atmospheric air, resulting in an output of almost pure oxygen. CPAP is continuous positive airway pressure, which can assist children with severe respiratory distress. The bubble-CPAP concentrator delivers both oxygen *and* continuous positive airway pressure, the level of which depends on the distance the tubing is under the water in the bottle.

Setting up the bubble-CPAP concentrator

Follow the steps below to use the bubble-CPAP concentrator:

1. Position the concentrator so that it is at least 30 cm away from walls or curtains, so that the inlet opening at the back is not obstructed.

2. Plug the power cord into the mains electricity supply, and turn on the concentrator.

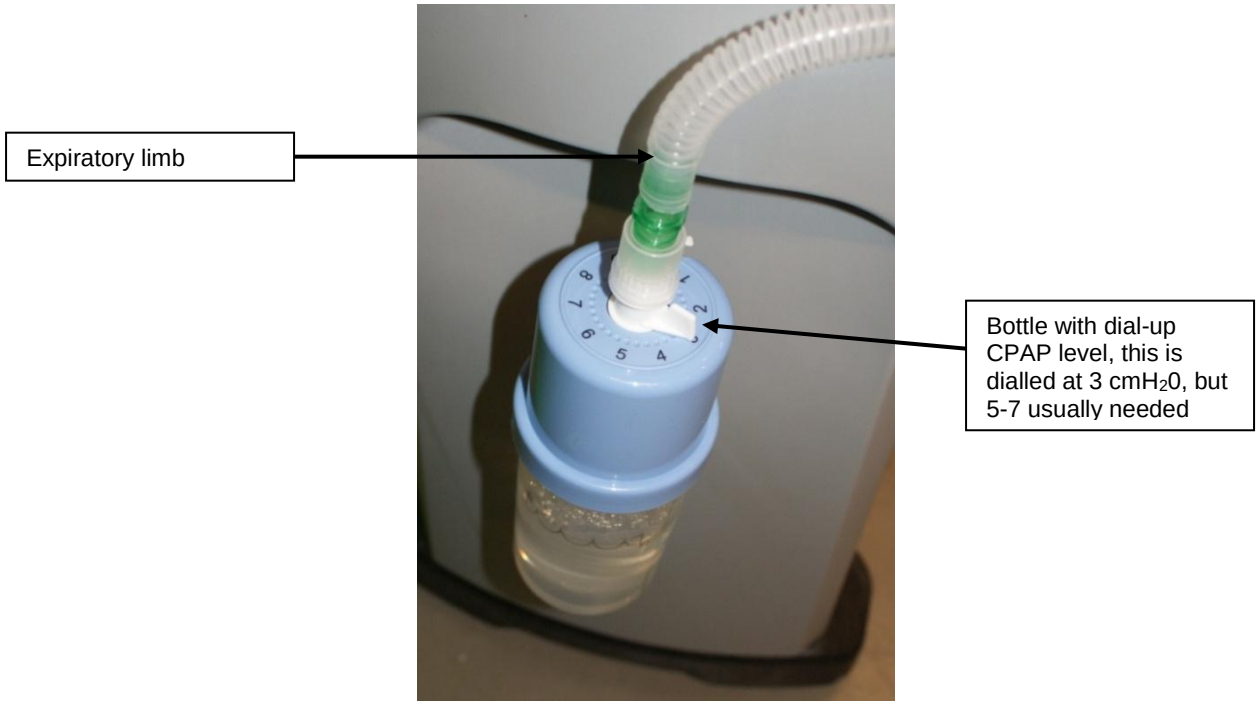
3. Turn on the concentrator (switch on the console). Always have the oxygen flow dial turned on when you turn the concentrator on, this prevents a build-up of pressure inside the concentrator. Gas should flow immediately from the gas outlet. An orange light will go off when sufficient oxygen concentration is reached, usually within 10 minutes.

4. Fill the bottle to the level indicated with boiled water that has been allowed to cool to the level indicated, and screw back on the lid.

5. Connect the inspiratory limb of the circuit to the main gas outlet

6. Connect the expiratory limb of the circuit to the bottle.

7. Dial up the level of CPAP required: start at 7 cmH_2O.



8. Connect the nasal prongs to the child as with normal oxygen prongs

9. Dial the flows of air and oxygen required to see a constant stream of bubbles in the water. Start with 5 L/min of oxygen and 5 L/min of air for a 5kg child, and 3 L/min of oxygen and 3 L/min of air for a neonate. Check and record the flows dialled and the oxygen concentration this provides. A total flow of 10 L/min is sufficient in most cases to deliver CPAP, which you can see by continuous bubbling in the bottle. In smaller infants and neonates often a much lower flow will still deliver CPAP (continuous bubbles); often a total flow of 5 L/min will be enough.

10. Use the lowest total flow that provides bubbling (will depend on the size of the patient, the CPAP level required and nasal leak). Usually a flow of about 2L **per kg** per min is maximal (e.g. for a 6 kg child a total maximal flow of 12L).

11. Check the child for signs of respiratory distress, check the SpO_2, and check if there are bubbles in the bottle.

    a. If the SpO_2 is below 90% or the child has severe respiratory distress, first increase the **CPAP level to 8 or 10cmH_2O** and then, if no response the **oxygen flow meter** to as much as 8 L/min.

    b. If there are not continuous bubbles, check the nasal prongs are attached properly, and reposition them so they fit snugly inside the nostrils.

    c. If there are still not continuous bubbles, check for leaks along the circuit, and adjust the oxygen or air flows according to the chart below.

	SpO_2 >90% and only mild respiratory distress	**SpO_2 >90% but moderate to severe respiratory distress**	**SpO_2 <90%**
Bubbles	No immediate change needed, may be able to reduce CPAP level to 5 cmH_20 or reduce flow rates	Increase CPAP level	Increase CPAP level Increase oxygen flow
No bubbles	Check nasal prongs and check to see that there is no leak in the circuit Wean CPAP level and check if child still needs CPAP	Check nasal prongs and check to see that there is no leak in the circuit Increase air flow, check for bubbles Increase CPAP level	Check nasal prongs and check to see that there is no leak in the circuit Increase oxygen flow, check for bubbles Increase CPAP level

Respiratory Distress Score (RDS)

	Clinical feature	Mild = 1	Moderate = 2	Severe = 3
1	**Hypoxaemia**	Mild hypoxaemia SpO_2 90–93%	Moderate hypoxaemia SpO_2 85–89%	Severe hypoxaemia SpO_2 <85% or cyanosis
2	**Chest wall indrawing**	None or minimal	Moderate chest wall indrawing	Severe wall indrawing, tracheal tug, use of accessory muscles
3	**Respiratory sounds**	None or minimal	Intermittent grunting and/or nasal flaring	Grunting with every breath, nasal flaring, audible wheeze
4	**Feeding**	Normally	Difficulty with feeding or reduced feeding because of respiratory distress	Unable to feed because of respiratory distress or lethargy
5	**Heart rate**	<140	140-170	>170
6	**Respiratory rate**	<40	40-60	>60

Trials off CPAP and when to stop CPAP

When children who are clinically stable (have a low respiratory distress score and SpO_2 >92%) CPAP should be disconnected for 10–15 minutes, put on standard flow oxygen, and carefully examined for changes in clinical signs and SpO_2, to assess whether CPAP is still required.

Trials off CPAP are best done first thing in the morning, when there is likely to be adequate staff to observe the child throughout the day. If trials off CPAP are started in the late afternoon, low staff numbers overnight and the oxygen desaturation that sometimes occurs during sleep mean that there is a risk of hypoxaemia developing unrecognized overnight.

Children who have SpO2 <90% or a high RDS (>10) while still on CPAP or who are unstable or very unwell should not be given trials on room air.

Some children will become hypoxaemic rapidly when they are taken off CPAP, and this is a marker of very severe disease, increase their oxygen or put them back on CPAP immediately. You should be by the bedside, monitor the SpO_2 and watch the child to see if he/she develops cyanosis or severe respiratory distress. Instruct parents and nursing staff of what to observe also.

Steps in CPAP weaning

If the child on CPAP is clinically stable (have a low respiratory distress score and SpO_2 >92%) disconnect from CPAP as described below for 10–15 minutes, and carefully examined for changes in clinical signs and SpO_2, to assess whether CPAP is still required:

1. Wean the bubble CPAP level to off, wean air flow to off, and reduce concentrator oxygen flow to 2L/min (do not turn oxygen to 0 as the concentrator needs to have some gas flowing whenever it is running)

2. Check child after 15-30 minutes, record respiratory score. If <10 and SpO_2 > 95% wean off oxygen and turn off concentrator

1. Check at 15mins, 30mins and 1hr

2. If SpO_2 >95% on room air, stay off CPAP and off oxygen

3. If SpO_2 90-95% and RDS <7: put on standard oxygen using wall or cylinder oxygen and normal nasal oxygen prongs

4. **If SpO_2 <90% or RDS >10 put back on CPAP**: neonates bubbling CPAP level at 5cmH_2O, oxygen 5L/min, air 5L/min. More than 1 year start CPAP level at 7cmH_2O, oxygen 7 L/min, air 7L/min. Dial up if not bubbling or saturation steady or desaturate.

5. Trial off CPAP again in 24 hours if the child is stable.

6. Continue careful monitoring and care till full recovery and discharge

Children with acute respiratory disease should not be discharged until

1. their SpO_2 has been stable at >90% while breathing room air for at least 24 hours

2. danger signs have resolved

3. appropriate home treatment can be organized

4. the parents or guardian understand the danger signs to look for, when to return if the child becomes sicker, and when to return for a planned review

Cleaning of the circuit tubing and bottle

This is essential to reduce the risk of cross-infection. This should be done after every patient has used the CPAP, and weekly if the same child is on CPAP for over a week. A spare circuit is essential to replace the one that is being cleaned without interruption to the child's treatment.

The CPAP circuit (inspiratory and expiratory limb, bottle and lid and connections) must be thoroughly cleaned as follows:

1. **Wipe off any gross soiling. Clean first with detergent (soap)** to remove gross contamination (e.g. blood, sputum);

2. **Rinse with water that has been boiled and allowed to cool to tepid. Let it dry**

3. **Disinfect** before re-using.

    - Staff cleaning the equipment must wear protective clothing to avoid splash exposure or contact with dirty equipment: wear apron, gloves and glasses.

    - Good ventilation of the area is needed where you are cleaning the equipment

    - **What you need**

    - Soap for initial clean

    - Disinfectant solution: (sodium hypochlorite 0.05% or household bleach, diluted to 0.05% hypochlorite. The household bleach bottle will indicate its strength, dilution is essential)

    - Sink or buckets to clean equipment

    - Brush to clean both inside and outside of circuit. All brushes and cleaning implements must be properly cleaned after use – soap water and drip dry

    - Gown or waterproof apron, mask and water-proof gloves

    - Drying rack

    How to wash and disinfect

    1. Wash hands

    2. Prepare detergent (soapy water) and disinfectant solution wearing personal protective equipment (PPE): gown or impermeable apron as a minimum, eye protection and surgical mask for bleach solution

3. Wash first in soapy water, to remove blood and respiratory secretions. In clean sink or bucket brush the equipment under water to prevent splash and ensure all visible soiling is removed, rinse with water that has been boiled but allowed to cool to tepid

4. Let dry

5. Wash next in diluted bleach or disinfectant. Bleach needs one hour of soaking. Soak all items together, do not keep putting one in and taking one out. Once used bleach should not be re-used or kept in storage, discard after use.

6. Rinse with water that has been boiled and cooled to tepid (rinse also inside, for example, using a sterile syringe), let it drip dry over the sink, do not leave it coiled on the sink.

7. Remove all protective gear (apron, gloves, mask) and wash hands thoroughly

8. Check that there is no pooled water in the circuit. Store the circuit and bottle in a clean plastic bag (labeled and dated). Store in the dry and clean area (separate from a soiled equipment area)

Routine cleaning and maintenance of the CPAP-concentrator

Each week the oxygen concentrator will require approximately 30 minutes of attention. Concentrators have a large particulate filter over the air inlet opening (usually at the back of freestanding or portable models). This filter stops dust and other airborne particles from entering the unit. The filter should be removed and cleaned in warm soapy water, completely dried with an absorbent towel and replaced. Have a spare dry filter to replace with so there are minimal interruptions to the concentrator function.

The exterior of the oxygen concentrator should be cleaned with a mild disinfecting cleaning agent or a diluted solution of bleach (usually 5.25% sodium hypochlorite). A solution in the range of 1:100 to 1:10 of bleach to water can be used effectively. Allow the solution to remain on the surface for 10 minutes and then rinse off and dry.