

Practical Application of CPAP

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Continuous positive airway pressure (CPAP) applied to premature infants with RDS re-expands collapsed alveoli, splints the airway, reduces work of breathing and improves the pattern and regularity of respiration. Atelecto-trauma (repeated opening and collapse of the alveoli), biotrauma (intubation of the airway) and volutrauma (overstretching of the alveoli), the key determinants of VILI (ventilator induced lung injury) are minimal or absent with this mode of ventilation.

Indications

The prime requirement for starting CPAP in a neonate is the presence of good respiratory effort. CPAP is indicated in spontaneously breathing **premature infant** with respiratory distress (tachypnea, retractions or grunt), recurrent apneas not responding to medical management and post extubation from mechanical ventilation. In at-risk neonates for respiratory distress syndrome, CPAP could be started at the earliest sign of respiratory distress (mild to moderate retractions and or grunt). CPAP is indicated in **term neonates** with respiratory distress and low volume lungs (retractions, grunting, posterior ribs spaces less than 6 on the CXR).

In neonates with poor respiratory efforts, congenital diaphragmatic hernia, tracheo-esophageal fistula, choanal atresia, cleft palate and in those with severe cardio-vascular instability, CPAP is contraindicated. CPAP is also contraindicated, when the pH is less than 7.25 with a PaCO₂ > 60mm of Hg.

Essentials of CPAP

The steps of initiation of CPAP would include

1. Preparing the circuit, the bubble chamber and the machine
2. Fixing the cap
3. Securing the nasal prongs
4. Connecting the circuit
5. Insertion of orogastric tube
6. Setting of pressure, FiO₂ and Flow

Preparing the machine, circuit and the bubble chamber

Connect the machine to the air and oxygen gas inlets. The circuit should have an inspiratory and an expiratory limb. The inspiratory limb of the circuit ensures gas flow from the machine to the humidifier and then to the patient. It has a heater

wire in it for heating the gas till it reaches the patient. The expiratory limb is connected to the bubble chamber. Fill the bubble chamber and the humidifier with distilled water to the required level.

Fixing the cap

When fixing the cap ensure to cover the ears. When using 'Fisher and Paykel' interface select the size after measuring the head circumference. For Hudson prongs the best fitting prongs comes with appropriate size cap. Indigenously prepared cap should fit snugly on to the head.

Securing the nasal prongs

This is the most important and critical step in the initiation and maintenance of CPAP.

1. **Choose the correct prong size:** The correct prong size is one which fits snugly into the nostrils without distending the alae nasi. When using Fisher and Paykel or Argyle, choose the correct prongs and the connectors using the guidelines available with the kit. Hudson prongs come in 6 sizes. Use the following guidelines for selection of nasal prongs
 - a. Size 0 Birth weight < 700gms
 - b. Size 1 Birth weight 700-1000gms
 - c. Size 2 Birth weight 1000-2000gms
 - d. Size 3 Birth weight 2000-3000gms
 - e. Size 4 Birth weight 3000-4000gms
 - f. Size 5 Birth weight >4000gms
2. **Secure the nasal prongs to the nostrils**
 - a. Fisher and Paykel: Choose the correct nasal tubing. Connect the nasal prongs to the nasal tubing as described in the starter kit. Fix the nasal prongs to the cap using the threads that come with the connector kit. Secure the nasal tubing to the cap and support them appropriately, to avoid their weight falling on to the nostrils.
 - b. Hudson prongs: Secure them with Tegaderm and Velcro to the nostrils and fix the inspiratory and expiratory circuits to the cap using safety pins and rubber bands.
 - c. Argyle prongs: Choose the appropriate size prongs and fix it to the cap.

Connect the circuit

In case of Fisher and Paykel connect the circuit to the nasal tubing and for Hudson the circuit directly connects to the nasal prongs. Stabilize the head of the neonate to prevent dislodgement of nasal prongs.

Insert orogastric tube

As soon as the patient is connected to the bubble CPAP, an orogastric tube should be

inserted. It should be secured either to the lower lip or to the nasal prongs. The open end of orogastric tube should always be above the level of stomach, to constantly deflate it with the excess gas that enters it during CPAP.

Setting of pressure, FiO₂ and Flow

1. Pressure

- This is increased or decreased by increasing or decreasing the depth of immersion of expiratory limb into the bubble chamber (water level being constant) or directly by dialing the knob on the pane when administering CPAP with a ventilator. Pressure is adjusted by regulating the flow in a flow driver.
- Start with a pressure of 5cm H₂O in case of RDS or Pneumonia and a pressure of 4cm H₂O if CPAP is for apnea management
- Pressure is adjusted to minimize chest retractions and to observe 6 to 8 posterior rib spaces on the Chest x ray.

2. Flow

The flow should be minimal to produce continuous bubbling in the bubble chamber. It varies depending on the pressure set, the lung disease, weight of the baby and the leaks in the circuit or from patient's mouth. In the absence of a blender, first set the total flow and then set the air and oxygen gas flow to get the desired FiO₂. In most babies gas flows of 2 to 5L/min are sufficient

3. FiO₂

- Start with a FiO₂ of 40 to 50% and after adjusting the pressure, titrate the FiO₂ to maintain SpO₂ between 89% To 94%
- In the absence of a blender, for adjusting FiO₂, mix air and oxygen gas flows to get the desired FiO₂ using a matrix or a chart or the following formula

$$\text{FiO}_2 \text{ delivered to the patient} = \frac{(1 \cdot \text{oxygen flow}) + (0.21 \cdot \text{air flow})}{\text{Total gas flow reaching the patient}}$$

Maintaining and Monitoring of a neonate on CPAP

This includes :

- ◆ Adjustment of pressure, FiO₂ and Flow
- ◆ Maintenance of CPAP interface/circuit and
- ◆ Monitoring for adequacy and complication of CPAP.

Adjustment of pressure, FiO₂ and Flow

Ideal range of pressure for a baby on CPAP is from 4cm to 8 cm of water. Increase or decrease pressure to minimize chest retractions, maintain 6 to 8 posterior rib spaces on the CXR and to maintain PaO₂ > 50mm Hg. Inadequate pressure results in alveolar

atelectasis and increased chest retractions. Silverman scoring is an objective method to assess the efficacy of CPAP. High pressure results in hyper-inflated lungs decreased venous return, poor capillary perfusion and metabolic acidosis.

Ideal FiO_2 for a baby on CPAP is from 21% to 60%. Pressure and FiO_2 adjustments are done to improve oxygenation. FiO_2 is adjusted to maintain SpO_2 between 89% to 94%. Always increase pressure before FiO_2 for better oxygenation.

Flow changes are made only for delivering adequate pressure. Too high flows results in wastage of gases, turbulence, and inadvertent high pressure. The ideal flow is the minimal flow which results in continuous bubbling in the bubble chamber.

Maintenance of circuit and nasal interface

Meticulous nursing care is required for proper maintenance of CPAP interface and the circuit.

Every shift the nurse on duty should

1. Ensure correct position and fixation of the nasal prongs
2. Clean the nostrils with saline drops, suction the secretions and ensure patency of prongs
3. Prevent injury to the nasal septum by ensuring a gap between the nasal prongs and columella
4. Remove condensed water in the inspiratory circuit
5. Fill the humidification chamber and ensure that the gas reaching baby should be at 37°C and at 100% relative humidity
6. Fill the bubble chamber with distilled water
7. Record the depth of immersion of the expiratory limb in the bubble chamber

Monitoring of adequacy and complications of CPAP

The parameters that need to be monitored for assessing adequacy and complications of CPAP include

- ♦ **Vitals :** Heart rate, Temperature, Respiratory rate, Blood pressure and SpO_2
- ♦ **Assessment of circulation :** Capillary refill time, blood pressure and urine output
- ♦ **Scoring of respiratory distress.** It can be done with Silverman score or with Downe's score.
- ♦ **Abdominal distension,** bowel sounds and gastric aspirates to prevent CPAP belly
- ♦ **Neurological status :** Tone, activity and responsiveness
- ♦ **CXR :** It is done at the starting of CPAP and as and when there is a clinical deterioration
- ♦ **Blood gas :** It is done once or twice a day during the acute stage and later when clinically warranted. Capillary blood gases are preferred.

CPAP is considered to be adequate if a baby on CPAP is

- ◆ Comfortable
- ◆ Has minimal or no chest retractions
- ◆ Has normal CFT, Blood pressure
- ◆ SpO₂ is between 89% to 94%.
- ◆ Blood gas : PaO₂ is 50 to 80 mm Hg, PCO₂ is 40 to 60 mm Hg and pH is 7.35 to 7.45. Bubbling in the bubble chamber and also bubbling sounds on auscultations of the chest.

Weaning of CPAP

Weaning of oxygen and pressure is considered, when the clinical condition for which CPAP was indicated is passive. CPAP for apneas may be removed after 24 to 48 hours of apnea free interval. Wean pressure and FiO₂ in steps of 1cm and 5% to 10% respectively. Maintain the proportionality of settings as discussed earlier. Decrease FiO₂ before decreasing pressure. If a baby is stable on CPAP, first wean off the oxygen to 30% in steps of 5% and then wean the pressure to a minimum of 4 cm in steps of 1cm/change. When a baby is on a pressure of 4cms with a FiO₂ < 30% with normal saturations and minimal retractions, CPAP may be removed.

After the removal of CPAP the baby requires frequent change in posture, oral and nasal suction and occasionally saline nebulization for effective removal of secretions. For the 12 to 24 hours after removal of CPAP, careful monitoring is required for apneas, tachypnea, worsening retractions and bradycardia.

Failure of CPAP

CPAP failure is considered when the FiO₂ required is greater than 60% and pressure required is greater than 7 cm of water. A baby continuing to have retractions, grunting and recurrent apnea on CPAP should be considered for mechanical ventilation. Inability to maintain SpO₂ > 85% or PaO₂ > 50 mm of Hg with FiO₂ > 60% and pressure > 7cm of water and PaCO₂ > 60 mm of Hg on CPAP are also indications for mechanical ventilation.

Before considering CPAP failure ensure the following criteria

- ◆ Baby is not fighting the CPAP Interface
- ◆ Nasal prongs are of correct size and are in position
- ◆ Humidification is adequate and there is no condensation in the circuit
- ◆ Adequate pressure and FiO₂ were delivered (neck position, clear nostrils and airway)

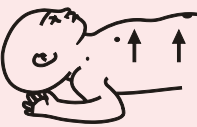






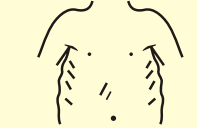







	UPPER CHEST	LOWER CHEST	XIPHOID RETRACTIONS	NARES DILATATION	EXPIRATORY GRUNT
Grade 0	 SYNCHRONIZED	 NO Retractions	 NONE	 NONE	 NONE
Grade 1	 LAG ON INSPIRATION	 JUST VISIBLE	 JUST VISIBLE	 MINIMAL	 HEARD WITH STETHOSCOPE
Grade 2	 SEE-SAW	 MARKED	 MARKED	 MARKED	 AUDIBLE

Figure : The Silverman score for assessing the magnitude of respiratory distress. (From Avery, M.E., And Fletcher, B.D. : The Lung and Its Disorders in the Newborn. Philadelphia, W.B. Saunders Company, 1974) (Courtesy of W.A. Silverman)

Key Messages

- ◆ The prime requirement for starting CPAP in a neonate is the presence of good respiratory efforts
- ◆ CPAP is contraindicated in neonates with poor respiratory efforts, congenital diaphragmatic hernia, tracheo esophageal fistula, choanal atresia, cleft palate and in those with severe cardiovascular instability .
- ◆ Always increase pressure before FiO_2 for better oxygenation.
- ◆ Increase or decrease pressure to minimize chest retraction, maintain 6 to 8 posterior rib spaces on the chest X-ray and to maintain $PaO_2 > 50$ mm kg.