CHAPTER

3

Practical Application of CPAP

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Continuous positive airway pressure (CPAP) applied to premature infants with respiratory distress 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 should be started at the earliest sign of respiratory distress (mild to moderate retractions and or grunt). CPAP is also indicated in term neonates with respiratory distress and saturations less than 90% on hood oxygen.

In neonates with poor respiratory efforts, congenital diaphragmatic hernia, tracheo-esophagial 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 and PaCO2 >60 mm 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 or nasal mask

4. Connecting the circuit
5. Insertion of orogastric tube
6. Setting of pressure, FiO_2, 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 humidifier chamber with distilled water preferably using the autofill option. One may use clean water to fill the bubble chamber.

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 or nasal mask

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 the nostrils.

b. Hudson prongs: Secure them with Tegaderm and Velcro to the upper lip 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.

3 Fixing of nasal mask

Choose appropriate size mask. Avoid undue pressure on the nose while fixing the mask to the nasal tubings and to the cap.

Connecting 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.

Insertion of 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

a. 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.

b. Start with a pressure of 5cm H_2O in case of RDS or Pneumonia and a pressure of 4cm H_2O for apnea management

c. Pressure is adjusted to minimize chest retractions and to observe 6 to 8 posterior rib spaces on the Chest x ray.

2. Flow

Keep the flow rate at 5 liters/min. Watch for bubbling in the bubble chamber. In case of poor or no bubbling check for leaks in the circuit or increase flow rate.

3. **FiO_2**

a. Start with a FiO_2 of 50% and after adjusting the pressure, titrate the FiO_2 to maintain SpO_2 between 90 to 94%.

b. In the absence of a blender, for adjusting FiO_2 mix air and oxygen gas flows to get the desired FiO_2 using a matrix or a chart or the following formula

$$FiO_2 \text{ delivered to the patient} = \frac{(1 \text{ Oxygen flow}) + (0.21 \text{ air flow})}{\text{Total gas flow reaching the patient}}$$

Maintenance and monitoring of a neonate on CPAP

This includes

- Adjustment of pressure, FiO_2 and Flow
- Maintenance of CPAP interface/circuit and
- Monitoring for adequacy and complication of CPAP

Adjustment of pressure, FiO_2 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 $PaO_2 > 50$mm 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 SpO2 between 90% 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.

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 clean 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 SpO2
- **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 monitoring**: bowel sounds and gastric aspirates to prevent CPAP belly

- **Neurological status assessment :** 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
- SpO_2 is between 90 to 94%.
- Blood gas : PaO_2 is 50 to 80 mm Hg, PCO_2 is 40 to 60 mm Hg and pH is 7.35 to 7.45.

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. Always wean pressure before weaning of FiO2. For a baby on FiO2 > 50% and CPAP pressure >5 cm, wean FiO2 till it reaches 50% and then wean the pressure. Once the FiO2 is at 50% wean it a level <30% before reducing CPAP pressure from 5 to 4 cm. When a baby is on a pressure of 4cms with a FiO_2-< 30% with normal saturations and minimal retractions, CPAP may be removed. One may use HHHFNC when weaning a baby from CPAP.

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 FiO_2 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 > 90% or PaO_2 > 50 mm of Hg with FiO_2 > 60% and pressure > 7cm of water and $PaCO_2$ > 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, are delivered (neck position, clear nostrils and airway)

Key Messages

- The prime requirement for starting CPAP in a neonate is the presence of good respiratory efforts
- When starting CPAP for a newborn with RDS, the earlier CPAP is started, better are the results.
- When starting CPAP for respiratory distress, start with pressure of 5cm, FiO2 of 50% and Flow rate of 5 liters/min.
- Always increase pressure before FiO2, 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 PaO2 > 50 mm hg.
- Nasal interface and nursing practice play a key role in the success of CPAP.

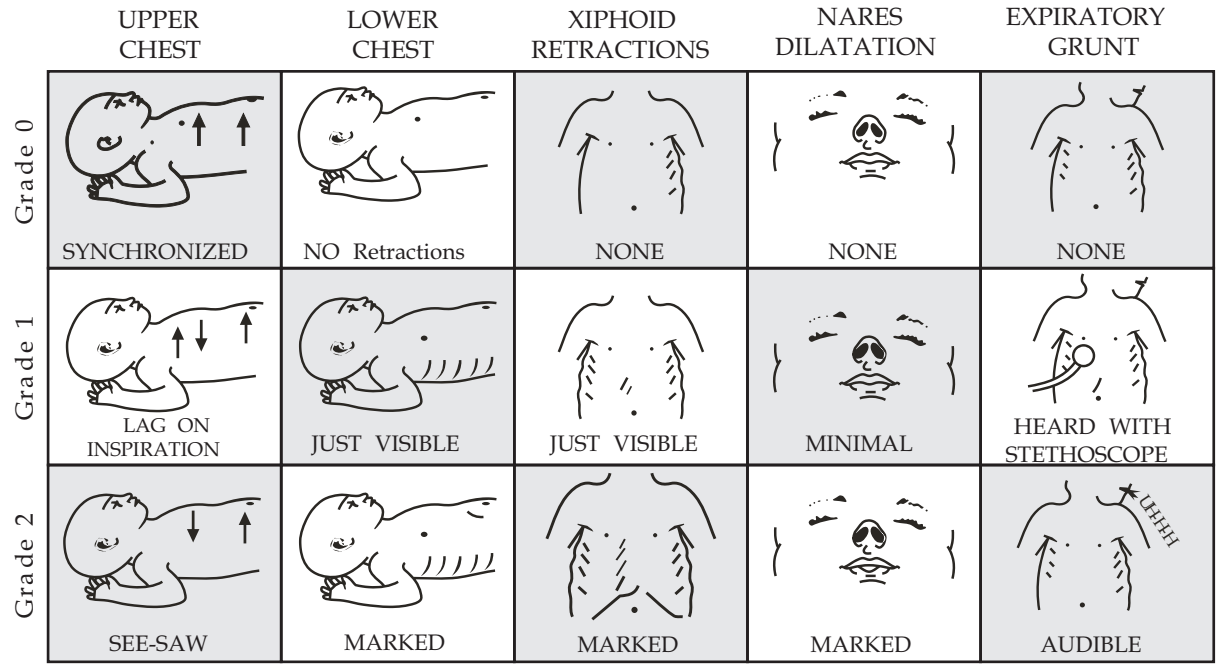

Figure : The silverman score for assessing the magnitude of respiratory distress. (from avery, M.E., and fletcher, B.D. : the lung and its disorders in the newborn. philadelphia, W.B. saunders company, 1974) (courtesy of W.A. silverman)