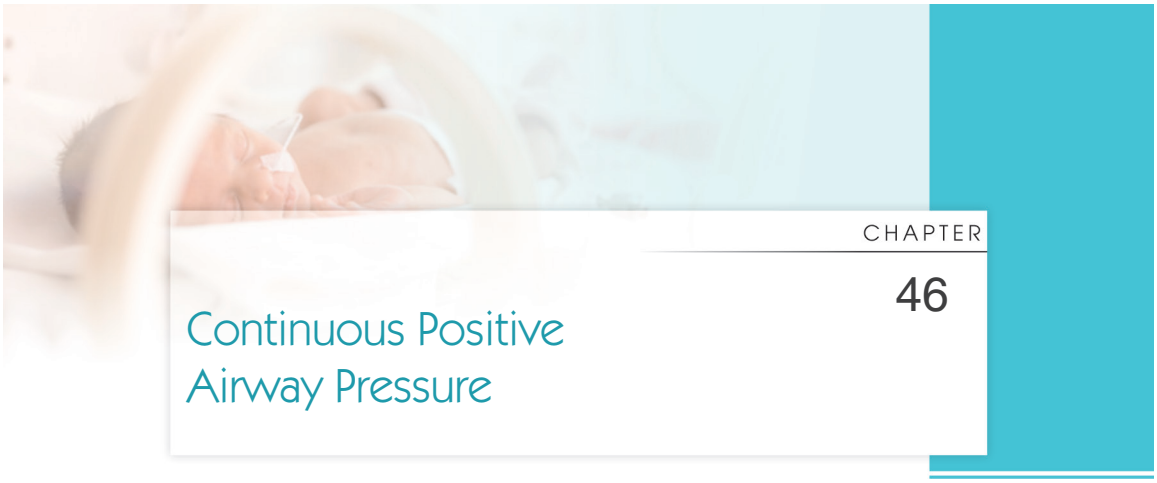

CHAPTER

46

Continuous Positive Airway Pressure

Continuous positive airway pressure (CPAP) refers to the application of positive pressure to the airway of a spontaneously breathing infant throughout the respiratory cycle. CPAP predominantly helps by preventing the collapse of the alveoli. Preterm infants have difficulty establishing and maintaining lung volumes due to surfactant deficiency, muscle hypotonia, slow clearance of lung fluid, and a compliant chest wall. CPAP results in the recruitment of alveoli, thus increasing the functional residual capacity (FRC) and preventing alveolar collapse.[1]

COMPONENTS

The components of a CPAP system are:

1. **Gas source:** To provide a continuous supply of warm, humidified, and blended gases, i.e. air and oxygen.
2. **Pressure generator:** To create positive pressure in the circuit.
3. **Patient interface/delivery system:** To connect the CPAP circuit to the infant's airway.

Devices Used for Pressure Generation

The pressure sources of CPAP can be broadly grouped into two types (Fig. 46.1):[2] We use continuous flow CPAP by both conventional ventilators and bubble CPAP devices in our unit.

Devices Used for CPAP Delivery (Patient Interface)

Various devices used for CPAP delivery include:

1. Nasal prongs (single/double or binasal)
2. Long (or) nasopharyngeal prongs
3. Nasal cannula
4. Nasal masks

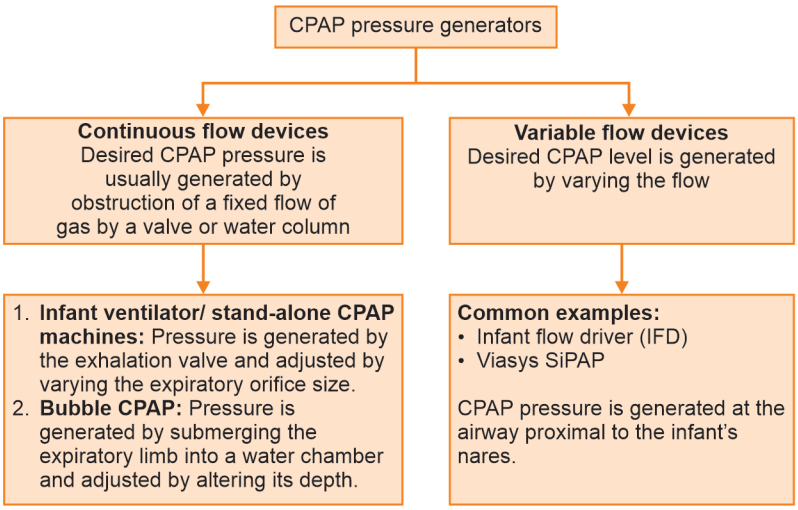

Fig. 46.1: Surfactant replacement therapy

Hudson, Argyle, IFD prongs, and RAM cannula are the commonly used short binasal prongs in neonates. A study comparing RAM cannula, Hudson prongs, and nasal masks found that the nasal masks delivered oropharyngeal pressure closer to the set CPAP.[3] Also, nasal masks may reduce the risk of treatment failure and nasal injury compared to nasal prongs.[4] On the other hand, the ToNIL study revealed that leakages are common for both masks and prongs, but the degree of the leak was significantly higher with prongs. Leakage can be significantly decreased using corrective measures such as adjusting the interface seal by external pressure, closing the mouth, changing interface size, and adjusting the cap and patient position.[5] *We use Argyle prongs, RAM cannula, or nasal masks to deliver CPAP.*

INDICATIONS FOR CPAP

The common clinical indications of CPAP have been listed in Table 46.1.

We use CPAP predominantly in preterm infants (<35 weeks and birth weight <1800 g) with respiratory distress, apnea of prematurity, delayed adaptation, and pneumonia; also, we extubate VLBW infants to CPAP routinely. We occasionally use CPAP in late preterm and term infants with respiratory distress secondary to TTNB, pneumonia, meconium aspiration syndrome, etc.

Table 46.1: Indications for CPAP
Common indications
1. Respiratory distress syndrome (RDS)
2. Apnea of prematurity
3. Post-extubation in preterm VLBW infants
4. Transient tachypnea of the newborn (TTNB)
Other indications
1. Pneumonia
2. Meconium aspiration/other aspiration syndromes
3. Pulmonary edema/pulmonary hemorrhage
4. Laryngomalacia/tracheomalacia/bronchomalacia

CONTRAINDICATIONS OF CPAP

The important contraindications for CPAP include:

1. Progressive respiratory failure with $PaCO_2$ levels >60 mm Hg or inability to maintain oxygenation (PaO_2 <50 mm Hg).
2. Congenital malformations of the airway (choanal atresia, cleft palate, tracheoesophageal fistula, congenital diaphragmatic hernia, etc.)
3. Severe cardiovascular instability (hypotension).
4. Poor respiratory drive not improved by CPAP.

GUIDELINES FOR CPAP THERAPY

When to Initiate Cpap?

Early CPAP: It is important to note that CPAP helps mainly by preventing an alveolar collapse in preterm neonates with surfactant deficiency. Once atelectasis and collapse have occurred, CPAP might not help much. Therefore, all preterm infants (<35 weeks of gestation) with any sign of respiratory distress (tachypnea/chest in-drawing/grunting) should be started immediately on CPAP. Infants of 32–34 weeks of gestation can have a little higher threshold (say, silverman score of at least 3–4 or RR of 70 bpm+) for initiating CPAP than infants <32 weeks of gestation (in whom CPAP must be started early for any distress or tachypnea).

Prophylactic CPAP: The Cochrane review that compared prophylactic CPAP with supportive care in preterm infants (mostly 29–32 weeks of gestation) concluded that there is insufficient evidence for any additional benefit with prophylactic CPAP.[7]

However, in preterm neonates born at or before 28 weeks of gestation, prophylactic CPAP administered immediately after birth in the delivery room (i.e. delivery room CPAP) has been found to reduce the need for mechanical ventilation and surfactant and also reduce the incidence of BPD when compared to intubation and mechanical ventilation.[6]

We do not practice prophylactic CPAP for preterm infants born after 28 weeks of gestation. However, we generally employ delivery room CPAP in preterm infants born at or before 28 weeks.

PROTOCOL FOR CPAP THERAPY

Table 46.2 outlines the protocol for CPAP therapy in the three most common neonatal conditions.

MONITORING WHILE ON CPAP

The following parameters need to be monitored while the infant is on CPAP:

1. Regular monitoring of respiratory rate, heart rate, SpO_2
2. Serial monitoring of:
   a. Severity of respiratory distress by using Downe's or Silverman score.
   b. Arterial blood gases (ABGs).
   c. Perfusion—CFT, BP, peripheral pulses, urine output.
   d. Abdominal girth.
   e. Nasal injury

During CPAP therapy, the target saturation and blood gases are SpO_2 90–95%; PaO_2 50–70 mm Hg; $PaCO_2$ 40–50 mm Hg.

HAZARDS/COMPLICATIONS OF CPAP

CPAP, though less invasive and generally safer than IMV, is not free of side effects.

1. Nasal irritation, damage to the septal mucosa, or skin damage and necrosis from the fixing devices are the most common adverse effects of CPAP. A nasal injury scoring system helps monitor skin integrity, septum, and other anatomic structures. Use of appropriate-size nasal prongs and proper nursing care, including frequent instillation of saline drops in the nostrils, ensuring an adequate gap between the prongs and the

Table 46.2: Protocol for CPAP therapy in the three common neonatal conditions			
	Indications		
	RDS	*Apnea of prematurity*	*Post extubation*
Initiating CPAP Pressure FiO_2	• Start at 5–6 cm H_2O • 0.3–0.5 (titrate based on SpO_2)	• Start at 4 cm H_2O • 0.21–0.4 (as decided by SpO_2)	• Start at 4–5 cm H_2O • Same or 0.05 above the pre-extubation FiO_2
What to do if there is no improvement? Pressure FiO_2	• Increase in steps of 1–2 cm H_2O to reach a maximum of 8 cm H_2O • Increase in steps of 0.05 (if oxygenation is still compromised) up to a maximum of 0.6	• Increase up to 5 cm H_2O (further increase is not warranted usually -may lead to hyperinflation) • FiO_2 increase does not help much	• Increase in steps of 1–2 cm H_2O to reach a maximum of 7–8 cm H_2O • Increase in steps of 0.05 to a maximum of 0.6
	Worsening respiratory distress, as indicated by Silverman scoring, hypoxemia (PaO_2 <50 mm Hg), or hypercarbia ($PaCO_2$ >60 mm Hg) despite CPAP pressure of 7–8 cm H_2O and FiO_2 of 0.5–0.6	Recurrent episodes of apnea requiring PPV	Same as for RDS

(*Contd.*)

Table 46.2: Protocol for CPAP therapy in the three common neonatal conditions (*Contd.*)

	Indications		
	RDS	*Apnea of prematurity*	*Post extubation*
Failure of CPAP	Likely to occur in infants with severe RDS with delay in initiation of CPAP/ administration of surfactant, associated sepsis, and in ELBW infants who have not received ANS[10,11]	Likely to occur in infants with central apnea and apnea secondary to sepsis/pneumonia	Likely to occur in ELBW infants and sepsis/pneumonia, PDA, metabolic acidosis, and collapse
Weaning from CPAP			
• When to wean?	• When there is no respiratory distress and SpO_2/blood gases are normal	• No episodes of apnea/ desaturation/bradycardia for at least 12–24 hours	• Same as for RDS
• How to wean?	• Reduce FiO_2 in steps of 0.05 to 0.3, then decrease pressure in steps of 1 cm H_2O every 24 hrs until 4 cm H_2O (infant's clinical condition will guide the speed of weaning). • Recent data suggest that in very preterm neonates sudden wean and pressure wean (decreasing pressure by 1 cm every 24 hours till 4 cm H_2O) were equally good choices. However, pressure wean is preferred in neonates <28 weeks of gestation.[12]	• Same as for RDS	

columella, and maintaining optimal humidity and temperature in the circuit would help minimize nasal injury. In some infants, protective barriers such as 'cannulaide,' hydrocolloid dressing, and alternating between nasal masks and prongs might also be considered to reduce the risk of injury.[7]

2. Pulmonary air leaks are the most severe adverse effects of CPAP.[8] They occur following over-distension of the lungs caused by inappropriately set high pressures.
3. Decreased cardiac output due to reduced venous return, decreased right ventricular stroke volume, and altered dispensability of the left ventricle.[9]
4. Impedance of pulmonary blood flow with increased pulmonary vascular resistance (with inappropriately high CPAP pressure).
5. Gastric distension and 'CPAP belly syndrome.' Routine use of an orogastric tube minimizes the risk.

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