CPAP Machines

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Continuous Positive Airway Pressure or CPAP is a modality of respiratory support in which increased pulmonary pressure is provided artificially during the expiratory phase of respiration in a spontaneously breathing neonate. Grunt in a baby with respiratory distress reflects an attempt to generate CPAP to keep alveoli open during expiration.

CPAP is distinct from Intermittent Positive Pressure Ventilation (IPPV) or Intermittent Mandatory Ventilation (IMV) in which breathing is taken over by the ventilator machine completely and an increase in pulmonary pressure occurs during both inspiratory as well as expiratory phases.

CPAP results in increased functional residual capacity (FRC) thus decreasing ventilation perfusion mismatch and better gas exchange. It results in splinting of upper airway thus decreasing airway resistance. These physiological effects result in decreased work of breathing and conservation of surfactant. However, excessive amount of CPAP can result in pulmonary air leaks and increase in pulmonary venous pressure. This can adversely affect the brain (increased risk of IVH) and heart.

An ideal CPAP delivery system consists of:

- A continuous supply of warm, humidified, blended gases at a flow rate of 2-3 times the infants minute ventilation
- A device to connect the CPAP circuit to infant's airway
- Means of creating a positive pressure in the CPAP circuit. (Fig. 1)

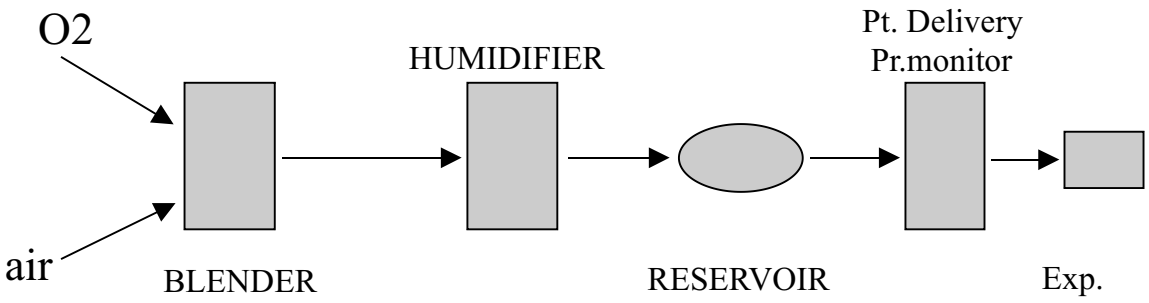


Figure 1: CPAP System

CPAP delivery systems

1. Ventilator

Ventilator is the ideal system to provide CPAP, but is expensive. It has blender for oxygen-air mixing, FiO_2 dial, humidifier, safety feature and a system to warm the gases. One simply has to switch over to CPAP mode and connect it to the baby.

2. CPAP system

CPAP system which delivers pressure and gases are available in Indian market. An ideal system must have the following capabilities:

1. End expiratory pressure of 0-15 cm water.
2. Humidification of up to 100%
3. Gas flow 5-8 L/min
4. Warming of gases to 34-37ºC.
5. Blending of oxygen air mixture (FiO_2 range of 0.21-1.0)
6. Display of FiO_2
7. Safety device against excess pressure
8. Tubing made of medical grade material with low dead space
9. Patient outlet to fit on to standard nasal prong system
10. Sterilizability of tubing.
11. Low noise compressor
12. Capability to run continuously for days and weeks
13. Good aesthetics, easy caring
14. Easy maintenance
15. Reasonable cost

Unfortunately none of the CPAP machines recently marketed in India have the above features.

3. Improvised system

Several books show a simple CPAP system using under-water system. In principle this system is doable, albeit cumbersome. But, in India, where air-oxygen blenders are not available, it has to be used only with 100% oxygen. This means we will always deliver 100 percent oxygen with locally made CPAP which is not rational. It is, therefore, not a good method to be used in practice.

Patient interfaces for providing CPAP

Nasal prongs

Nasopharyngeal prongs

Nasopharyngeal tube

Face masks

Prerequisites for a good CPAP delivery system

- Flexible light weight tubing
- Ease of application and removal
- Low resistance
- Soft & relatively atraumatic
- Simple and easy to use
- Cost effective

Types of CPAP based on gas flow

CPAP is divided in to two types depending upon type of flow viz. continuous flow and variable flow CPAP

(1) Continuous flow CPAP: In this type, a neonate is provided a continuous fixed flow of gases irrespective of the phase of respiration. Ventilator derived CPAP, conventional stand alone CPAP machines and Bubble or water-seal CPAP are perfect prototypes.

Bubble CPAP: Was first described and used in Columbia University under the name of Hudson CPAP in 1970s. In this, warm and humidified blended gas flows to the infant via nasal prongs. The distal end of the expiratory tubing is immersed in sterile water (addition of acetic acid makes the water bacteriostatic) to a specific depth to provide the desired level of CPAP e.g. the tubing is immersed to a depth of 5.0 cm to provide CPAP of 5.0cm H_2O. Bubble CPAP with the combined effects of CPAP and pressure

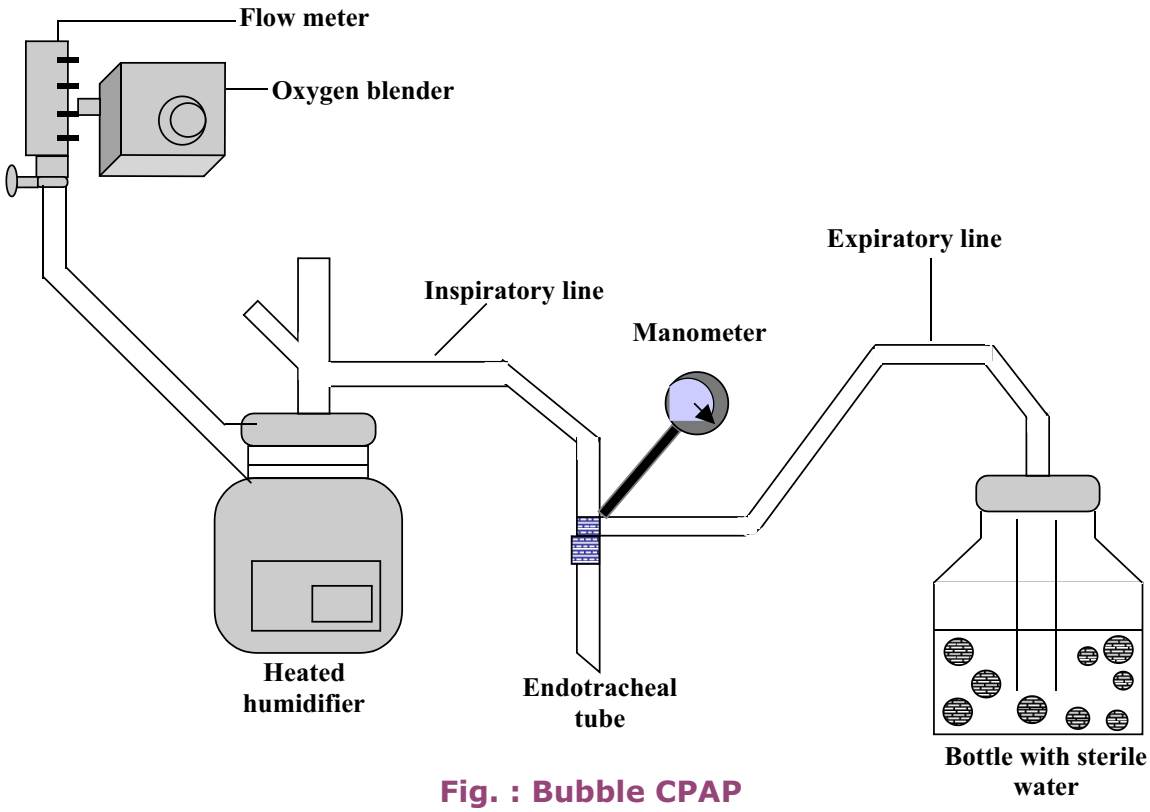


Fig. : Bubble CPAP

oscillations from the bubbles provides a lung protective, safe and effective method of respiratory support to spontaneously breathing neonates. Bubble CPAP effectively maintains FRC. The bubbling is also associated with the pressure oscillations, which get reverberated back into the infant's airway and may provide gas exchange through the principle of facilitated diffusion. This physiologic effect of bubble CPAP may help improve gas exchange and reduce the infant's work of breathing. Bubble CPAP may reduce the need for intubation, mechanical ventilation and reduce the incidence of chronic lung disease (CLD).

Hudson CPAP: Hudson prongs come in six different sizes for varied birth weight groups with cap and patient circuits with heated humidified wires. The prongs are applied using tegaderm and velcro ; stabilized usi ng safety pins on the woollen cap. The expiratory limb dips in the water bottle; the water level is the cpap pressure in cms of water.

(2) Variable/Dual flow CPAP

Variable flow CPAP generates CPAP at the airway proximal to the neonate's nares. It uses Bernoulli effect via dual injector jets directed towards each nasal prong in order to maintain constant pressure. If the neonate needs more inspiratory flow, the venturi action of the injector jets entrains additional flow. Due to Coanda effect during spontaneous expiratory effort there is fluidic flip which causes flow to flip around and to leave the generator chamber via the expiratory limb. A residual gas pressure is provided by the constant gas flow, which enables stable gas delivery at a desired pressure during the entire respiratory cycle. The fluidic flip mechanism reduces the work of breathing almost to one fourth of the continuous flow CPAP in which neonate has to exhale against the full continuous flow of gas. It is also found that variable flow maintains better uniform pressure level than continuous flow. Still, cost and free availability are the limiting factors.

Coanda effect: This phenomenon is caused when an air stream passes by a wall and turbulent gas flow causes an attachment of the stream to the wall. As gas travels faster over a pocket formed by turbulent air, the air stream is "pulled" closer to the wall.

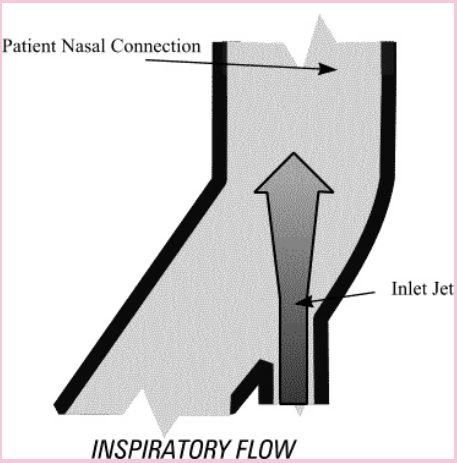
Basic components of variable flow CPAP are

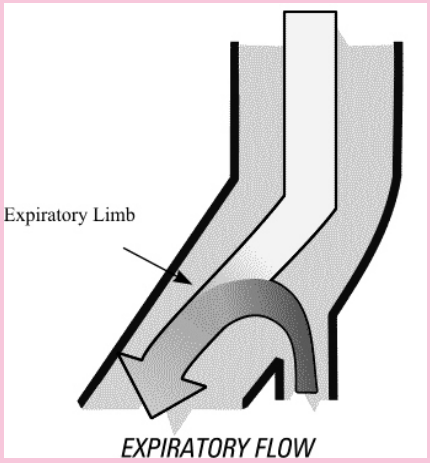
1. Flow driver: Provides adequate flows of appropriately blended gases.
2. Humidifier
3. Flow generator
4. Patient interface
5. Circuit
6. Fixation appliance

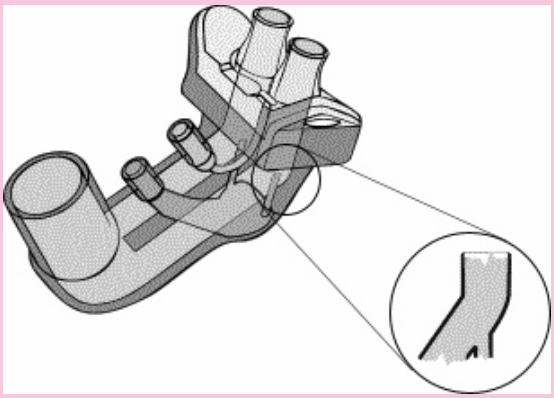
Figure: Exhibiting Coanda effect (Showing Infant Flow generator with Fluidic Flip effect)

Examples:

1. Infant flow system
2. Arabella







3. SensorMedics CPAP generator-SIPAP
4. Medijet

All four generators work on same principle of fluidic flip, have subtle differences

Medijet nCPAP Generator

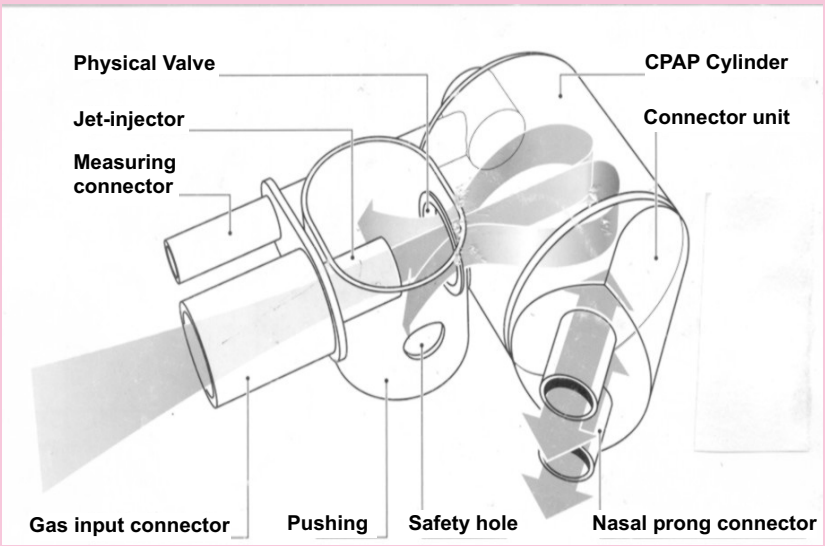


Table 2: Available CPAP machines in Indian market				
S.No.	Make	Dealer	Principals	Cost
1.	Indian CPAP	Phoenix Medical Meditrin Zeal Medical System Lectromedik Shreeyash	Phoenix Medical Meditrin Zeal Medical System Lectromedik Shreeyash	Rs 40,000 to 1,00,000/-
2.	Bubble CPAP	Fisher & Paykel Hudson	Fisher & Paykel Hudson	Rs 1,60,000/-
3.	Dual Flow CPAP a. SIPAP b. IFD c. Arabella D. Medijet	Rohanika Criticare India Pvt Ltd Trivitron, Chennai Pulmocare Consultants Phoenix Medical	Sensor medics, Viasys EME, UK Trivitron Medijet Phoenix Medical	Rs 23,00,000/-

Table 3: Patient interfaces available for CPAP			
S.No.	Make	Dealer & Address	Cost
1.	Argyle prongs	SB Medicare Pvt Ltd Mr JM Rishi Mb.: 9810117939 djg_48@rediffmail.com	Rs. 800/- available in three sizes <1 kg ; 1-1.5 kg; > 1.5 kgs
2.	Hudson prongs	a. Telflex medicals pvt ltd Blue Haven, N019, Harrington Road, Chetpet, Chennai-6003031 Ph.: 919841722791/04428365040 Email: ashok@teleflex-ind.com b. Hudson RCI CNC Medical Devices, 262 Adi Mansion, Dr Cawasji Hamusji Street, Mumbai -400002 Mb 9820062869 Email cncindia@vsnl.com	Rs. 1500/- six sizes with cap and patient circuit
3.	Nasopharyngeal prongs	Vygon India Pvt Ltd B 17/ sector 34, Info city Gurgaon-122001 0124-4002801/802 www.vygon.com	Rs. 500 for the prongs
4.	Fisher and Paykel	Fisher and Paykel India Branch Office, 339/1,HIG, A sector, 2nd stage extension, Yelahanka New Town, Bangalore, 560064 919849041888, 918042844000	Nasal prongs Rs. 380 Nasal tubing Rs. 800 Caps Rs. 500 Circuit Rs.2200