CHAPTER

1

Science & Physiology of CPAP

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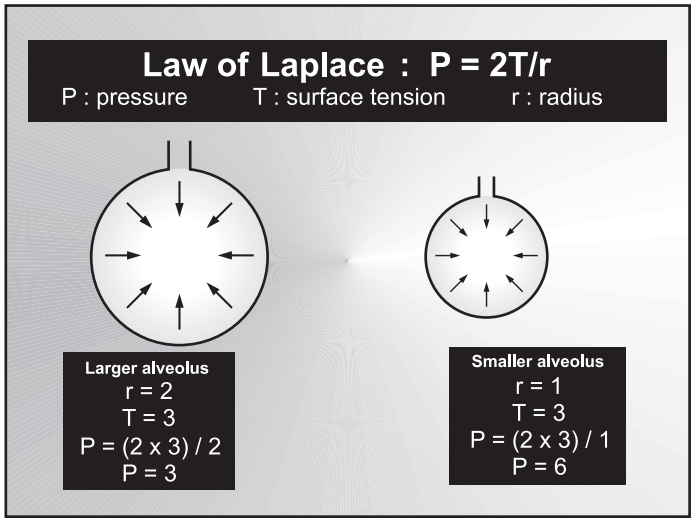
CPAP, also called continuous distending pressure (CDP), refers to the application of continuous pressure during both inspiration and expiration in a spontaneously breathing baby. By providing constant airway pressure, the alveoli are kept open which increases the functional residual capacity (FRC) of the lungs resulting in better gas exchange.

Effects of CPAP

1. In a baby with hyaline membrane disease (HMD), the FRC is usually reduced below the closing volume (volume below which the terminal airways connected to alveoli get closed). CPAP increases the FRC to a level above the closing volume so that the terminal airways remain open throughout the respiratory cycle.

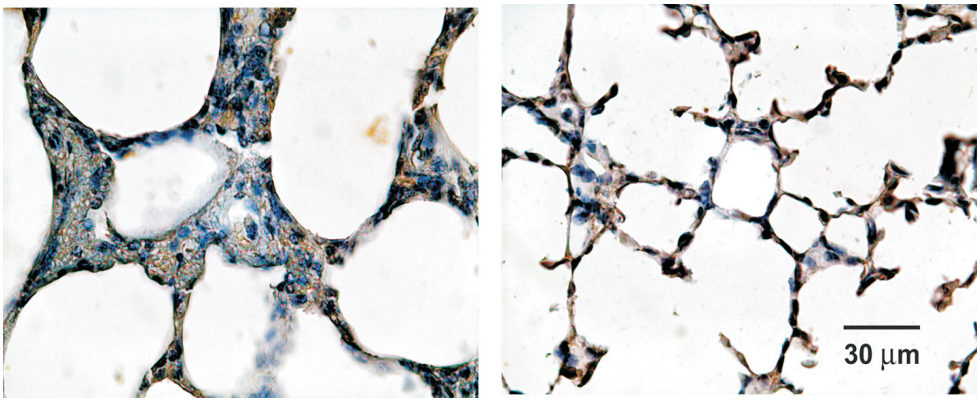
2. According to Laplace's law, an alveoli lined by water molecules exerts inward pressure to collapse the alveoli. This is determined

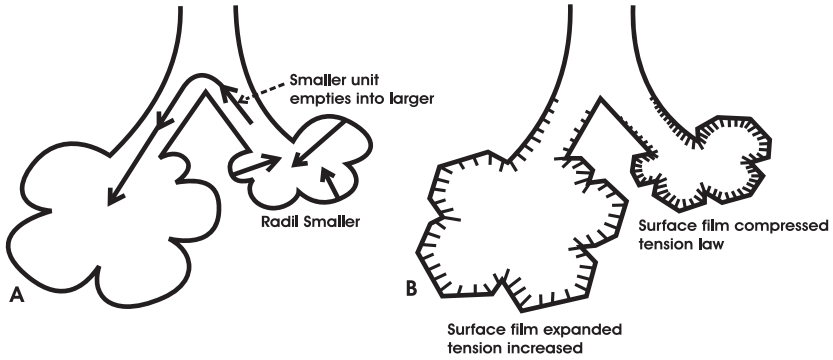


by the formula:

P = 2T/R (P is inward pressure making alveoli to collapse, T is surface tension and R is radius of the alveoli)

Advantages of CPAP





Thus smaller (diameter) alveoli will have a tendency to empty into larger (diameter) alveoli connected to each other. If the surface tension is reduced by giving exogenous surfactant, the inward pressure which leads to collapse can be reduced. By giving CPAP, one neutralizes the inward collapsing pressure. The net effect of both is more than additive. This principle is applied in clinical practice for INSURE (Intubate give Surfactant and Extubate to CPAP).

Physiological benefits

CPAP

- results in improved oxygenation, wash out of CO2, and better blood pH.
- splints the upper airways thus preventing obstructive apnea.
- stimulates 'J' receptors by stretching the lung/ pleura and providing positive feedback to respiratory centre by Hering Bruer reflex.
- results in better Type II-pneumocyte function and even recycling of surfactant thus contributing to early recovery from HMD.

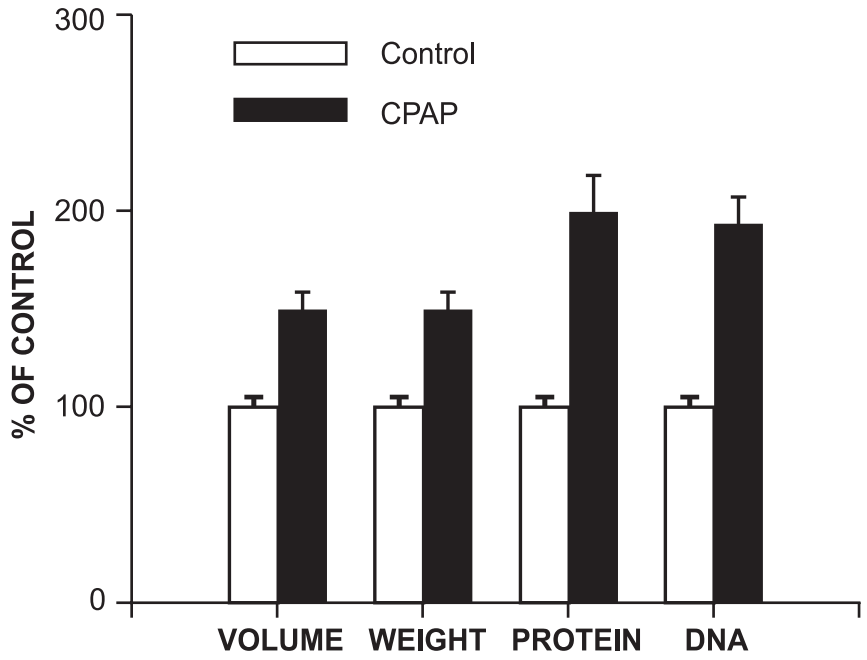
- results in better ventilation-perfusion match, improved minute ventilation and decreased work of breathing.

Disadvantages of conventional ventilation (CV)

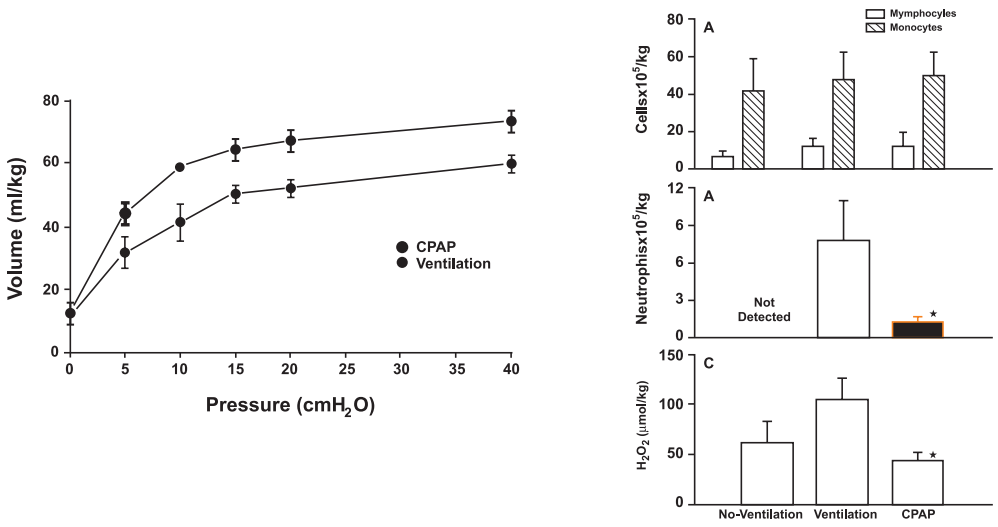
CV of premature lung results in inflation and deflation of alveoli at high pressure (Barotrauma); tidal volumes (volutrauma); few alveoli collapse & reopen from collapsed stage resulting in atelecto-trauma. In addition, endotracheal tube is a foreign material resulting in inflammation & infection (Biotrauma). Using nasal CPAP would avoid most of the ill effects of mechanical ventilation. Use of CV results in rupture of interalveolar septa thus decreasing the surface area for gas exchange despite increasing lung volume. In animal models, as little as 72 hours of CV has been shown to result in thickened alveolar septa.

a. Effect on lung growth

CPAP promotes growth in premature lung, as evidenced by increased DNA and protein per gm of lung tissue following CPAP application, while conventional ventilation initiates inflammatory response in the lung as evidenced by increased polymorphs and free oxygen radicals in the lung lavage.



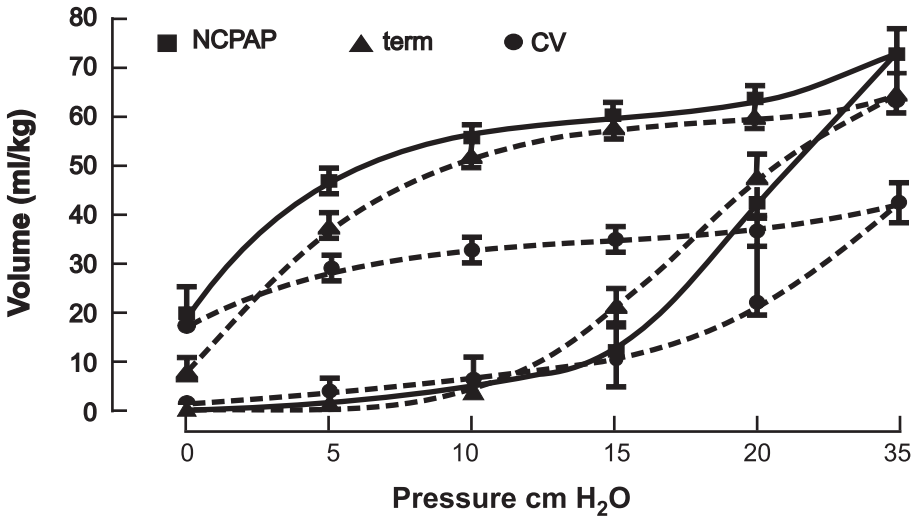
Lung volume, lung weight, protein and DNA content at the end of study were higher in CPAP-group than in control group ($P<0.01$). Strain-induced growth of the immature lung. Zhang S. et al. J. Appl Physiol 1996;81:1471-6



(Jobe AH: Pediatr. Res. 2002)

b. Effect on compliance

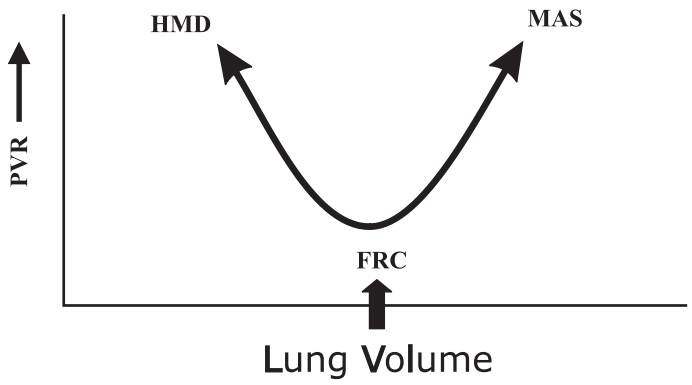
Animal experiments have demonstrated that lung compliance of premature lung following 28 days of CPAP application either matches that of a term lung or is better. In contrast lung compliance is reduced following conventional ventilation.



(Thomson MA AJRCCM 169:1054, 2004)

c. Effect on pulmonary vasccular resistance

By providing optimal CPAP , the lung is kept open at the FRC. The architect of blood vessels in the lung is such that, PVR is least at FRC and increases when the lung volume is reduced below FRC (HMD) or increased above FRC (Meconium Aspiration Syndrome).



d. Work of breathing

CPAP dilates terminal airways thus decreasing resistance to air flow, improving tidal volume for spontaneous breaths. Overall minute ventilation improves, resulting in washing down the CO,. The pressure splints the chest, improves co-ordination of chest and diaphragm movements thus resulting in decreased work of breathing.

Based on physiological principles and studies on animal models, there is strong evidence to use early CPAP as a primary modality with or without surfactant for babies with respiratory distress syndrome.

References

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Notes