CPAP therapy in the Newborn

Thrathip Kolatat M.D.
Neonatal Intensive Care Unit
Department of Pediatrics
Faculty of Medicine Siriraj Hospital
Continuous Positive Airway Pressure (CPAP)
CPAP

- the application of positive airway pressure throughout the respiratory cycle during spontaneous respiration
- history
  - Harrison 1968: described grunting in neonates as naturally producing end-expiratory pressure
  - Gregory et al, 1971: introduced the clinical use of distending pressure in neonates
Physiologic effects of CPAP

- pulmonary mechanics
- cardiovascular stability
- pulmonary vascular resistance
Pulmonary effects

- decrease respiratory rate, tidal volume and minute volume
- regularization of respiration
- increase FRC and thoracic gas volume
- decrease lung compliance and dynamic compliance
- decrease total airway resistance
- protective effect on surfactant
Effect of CPAP on FRC in the infants with RDS
Effect of different CPAP levels on PaO$_2$
Cardiovascular effects

- compromise venous return results in diminished cardiac output
  - depend on lung compliance
  - sign and symptom: tachycardia, metabolic acidosis, hypotension, decreased dynamic compliance, carbon dioxide retention
- decrease peripheral and regional blood flow
- decrease oxygen available to tissue
- increase extra-pulmonary shunting secondary to an increase in pulmonary vascular resistance
Effects of CPAP

- Renal function
  - decrease renal blood flow
  - decrease urine output and urinary sodium excretion
  - increase antidiuretic hormone and aldosterone

- Gastrointestinal function
  - decrease gastrointestinal blood flow
  - abdominal distention (CPAP belly syndrome)

- Intracranial pressure (head box CPAP)
  - increase intracranial pressure
  - intracranial bleeding
Pressure volume curve

is divided into 3 regions

- region A: low lung volume, low compliance and high resistance. The P/V slope is low
- region B: optimal lung volume and increases lung compliance
- region C: high lung volume, low lung compliance
Type of CPAP
Clinical applications of CDP or CPAP

- respiratory distress syndrome
- meconium aspiration syndrome
- apnea of prematurity
- postoperative thoracotomy
- patent ductus arteriosus
- postoperative celosomia
- weaning patients from primary lung disease
- differentiation of primary lung disease from primary cardiac disease
- as adjunct to intermittent positive ventilation
- sleep apnea
- bronchomalacia
Clinical applications of CPAP

<table>
<thead>
<tr>
<th>Low (2-3 cm H₂O)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Use</strong></td>
</tr>
<tr>
<td>● maintenance of lung volume in VLBW infants</td>
</tr>
<tr>
<td>● during weaning</td>
</tr>
<tr>
<td>● during hyperventilation in PPHN</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Medium (4-7 cm H₂O)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Use</strong></td>
</tr>
<tr>
<td>● increasing lung volume in surfactant deficiency</td>
</tr>
<tr>
<td>● stabilizing areas of atelectasis</td>
</tr>
<tr>
<td>● stabilizing obstructed airway</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Use</td>
</tr>
<tr>
<td>--------------------------------------------------------------------</td>
</tr>
<tr>
<td>● preventing alveolar collapse with poor $C_L$ and poor lung volume</td>
</tr>
<tr>
<td>● improving distribution of ventilation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>High (8-10 cm H$_2$O)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Use</th>
<th>Side effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>● tracheal or bronchial collapse</td>
<td>● air leak</td>
</tr>
<tr>
<td>● markedly decreased $C_L$ or severe obstruction</td>
<td>● decreased $C_L$ if over distended</td>
</tr>
<tr>
<td>● preventing white-out or re-establishing lung volume during ECHO</td>
<td>● may impede venous return</td>
</tr>
<tr>
<td></td>
<td>● may increase PVR</td>
</tr>
<tr>
<td></td>
<td>● $CO_2$ retention</td>
</tr>
<tr>
<td>Ultrahigh (11-15 cm H$_2$O)</td>
<td></td>
</tr>
</tbody>
</table>
Tracheomalacia
<table>
<thead>
<tr>
<th>Disease</th>
<th>Physiology</th>
<th>Optimal CPAP level</th>
</tr>
</thead>
</table>
| Acute RDS                                    | • significant A-a gradient  
• rapid change compliance           | • PaO₂  
• oxygen consumption  
• oxygen delivery                 |
| Small premature infant weaning off CPAP      | • small A-a gradient  
• weak respiratory muscles  
• increased chest wall compliance | • lung compliance                                      |
| BPD on 60% oxygen                            | • decreased compliance  
• increased resistance            | • pulmonary mechanics: resistance, compliance               |
| 4-day-old RDS and PDA                        | • congestive heart failure and pulmonary edema                              | • balance between cardiac output and pulmonary blood flow    |
Clinical use of CPAP

- Clinical indications
  - Sign of atelectasis on chest film
  - Chest wall retraction
  - Require FiO₂ > 0.5
  - Display rapidly progressive lung disease

- Initial pressure setting
  - Nasal or nasopharyngeal: 6 cm H₂O
  - Endotracheal: 4 cm H₂O

- Follow up and weaning
  - Follow-up PaO₂ within 15-20 min.
  - Weaning
    - After oxygenation was improved
    - Extubation from CPAP 3-4 cm H₂O
Nursing care of CPAP

- method
  - nasal
  - nasopharyngeal
  - endotracheal tube
  - face mask

- components
  - oxygen
  - temperature and humidity
  - pressure

- nursing care
  - continuous care (oxygen, pressure)
  - care of airway
    - prevent obstruction
    - prevent irritation of nares
  - skin care
  - abdominal distention
  - NPO
Indication of CPAP

Atelectatic disorders

- \( \text{PaO}_2 \) below 50-60 mm Hg in \( \text{FiO}_2 > 0.6 \)
- recurrent apnea

Initial setup

- CPAP 6 cm H\(_2\)O
- increase 2-cm. increments q 15 min. to a max. of 10 cm H\(_2\)O or 12 cm H\(_2\)O
- increase \( \text{FiO}_2 \) 0.05-0.10 if \( \text{PaO}_2 < 50 \) mm H\(_2\)O
Respiratory distress syndrome

- Improve survival rate, especially larger infants
- Modify course of the disease
- Lower max. FiO\textsubscript{2} required
- Reduce total amount of time under O\textsubscript{2} and the need for mechanical ventilation
Early CPAP in RDS

- was proved to be more beneficial in the atelectatic disease
- lower peak pressure required in infants treated with CPAP
- enhance surfactant conservation
- reduce the need for IMV by 20%, except infants with birth weight <1500 g.
- improve mortality and decrease the incidence of BPD
- prevent need for prolong intubation which reduce the incidence of acquired subglottic stenosis
Failure of CPAP therapy in RDS

- very low birth weight infant
- late application of CPAP
- severity of RDS
- associated disease e.g. sepsis, hypotension
- infants with severe degree of extrapulmonary shunt
  (Fox and coworkers, 1977)
CPAP in apnea of prematurity

- the application of low-level CPAP decrease the incidence of apnea of prematurity (compared to other forms of stimulation)
  - improve oxygenation
  - stimulation or inhibition of pulmonary reflexes
  - alveolar stabilization
  - mechanical splinting of airway; reduce supraglottic resistance in both inspiration and expiration

- some investigators recommended the early use of CPAP as a preventive measure of apnea of prematurity
CPAP in an infant with MAS

- pathology of meconium aspiration
  - atelectasis
  - large airway obstruction
  - V/Q abnormalities
- application of low-to moderate level CPAP
  - resolution of atelectasis
  - stabilization of terminal airway
- incidence of pneumothorax: not increased
- precautions in case with PPHN
Adverse effects of CPAP

- pulmonary air leaks
  - type of CPAP
  - lung compliance
  - gestational age
- gastric dilation and rupture
- hypotension
- increase pulmonary vascular resistance
- chronic lung disease?
Complication of face mask CPAP