Lung Protective Ventilation in The Preterm Neonate

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Disclosure

• I have nothing to disclose.

Objectives

• Briefly review pulmonary development
• Review some unique aspects to newborn respiratory physiology
• Discuss Non-Invasive Ventilation as the best lung protective strategy

Fetal Lung Development

Mechanical ventilation

• What we need to do
  • Support oxygen delivery, CO\textsubscript{2} elimination
  • Prevent added injury, decrease ongoing injury
  • Enhance normal development

Mechanical ventilation

• Prevent added injury
  • Minimize invasive therapy
  • Optimize lung volume
  • Target CO\textsubscript{2}, O\textsubscript{2}
  • Use appropriate adjuncts
  • Manage fluids and nutrition
Mechanical ventilation

- Enhance normal development
- Manage fluids and nutrition
- Encourage patient-driven support
- Maintain pulmonary toilet carefully

Key concepts:
- Maintain adequate lung volume
- Inspiration: tidal volume
-Expiration: End-expiratory lung volume
- Support oxygenation and CO₂ removal
- Oxygenation: adequate mean airway pressure
- CO₂ removal: adequate minute ventilation

Support devices

Premies are Unique

- Compliant chest wall but stiff lungs
- Limited muscular strength and endurance
- Immature respiratory control
- Rapid RR
- Transitional circulation
- Small trachea; high ETT resistance
- Uncuffed ETT; leaks and difficulty in measuring TV
- Awake and breathing

Fetal Lung Development
**Bronchopulmonary Dysplasia**

**Best Lung Protective Strategy?**

- AVOID INTUBATION !!!

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**Invasive Ventilation**

Intubation & mechanical ventilation saved many babies with respiratory distress, but also introduced new complications.

**Traumatic Intubation**

- Esophageal intubation
- Esophageal perforation
- Tracheal perforation
- Vocal cord injury
- Subglottic stenosis

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**ETT Ventilation in 1st Week**

Infants ≤30 weeks receiving primarily ETT ventilation were at increased risk for BPD or death compared to those receiving non-invasive respiratory support

OR 3.1 (95% CI 1.3-7.8)

Adjusted for gender, BW, Sepsis, PDA, Race, Surfactant, & Time to regain BW.
Non-Invasive Ventilation

- HFNC
- nCPAP
- NIPPV
- INSURE

High-Flow Nasal Cannula

- Gas source
- Pressure relief valve 45cm H2O
- Nasal interface
- Humidifier

HFNC

12 physiologic studies 1993-2013
- Pressure delivered is variable and unpredictable
- Affected by mouth-opening, flow rate, and infant size

12 clinical studies 2005-2013
- Flow rates up to 8 lpm without significant morbidity
- HFNC more effective than low flow NC for preventing intubation
- Minimal differences versus nCPAP
HFNC vs. NCPAP

34+3 Premature Infants
GA <32 weeks

Extubated to HFNC 5-6 lpm or NCPAP 7cm

Ex tubation failure rate was equal

– Most likely due to apnea

HFNC Group

– Decreased nasal trauma compared to nasal prong CPAP
– Increased extubation failure <26 weeks
– Half HFNC failures rescued with NCPAP

HFNC Conclusions

Easy to use
Works fairly well
Pressure delivered is variable but may be excessive
Not as effective as NCPAP for more premature infants

Nasal CPAP Devices

Nasal Interface

– Long nasopharyngeal tube
– Single nasal prong
– Nose mask
– Short bi-nasal prongs
– Nasal cannula

Pressure Control

– Bubble CPAP
– Variable flow device
– Ventilator

Each device delivers controlled and relatively constant airway pressure

Nasal CPAP Effects

Splints open upper airway

– Reduces obstruction & apnea
Prevents alveolar collapse

– Reduces atelectasis
– Reduces QV mismatch
– Conserves surfactant

Nasal CPAP Complications

Leak

Trauma

COIN Trial

650 Premature Infants
GA ≥32 to 67 weeks

CPAP vs. Intubation in OR
CPAP Group:

– Decreased use of O2 at 28 days
– Increased pneumothorax

But...

– ½ CPAP group was intubated
– Initial CPAP was 8cm H2O
SUPPORT Trial
1316 Preterm infants
GA 24-27 6/7 weeks
CPAP vs. Intubation in DR
CPAP Group:
- Fewer intubated days
- Decreased need for post-natal steroids for BPD
But...
- ¼ CPAP group was intubated

NCPAP Conclusions
Easy to use
Helps prevent extubation failure
Reduces BPD compared to ETT ventilation
Commonly used devices can cause pressure injury

Nasal PPV Devices
Nasal Interface
- Long nasopharyngeal tube
- Single nasal prong
- Nose mask
- Short bi-nasal prongs
- Nasal cannula
Pressure Control
- Ventilator
- Variable flow device
Similar to CPAP, but pressure control must provide variable pressure at set rate

Nasal PPV Effects
Splints open upper airway
- Reduces obstruction & apnea
Prevents alveolar collapse
- Reduces atelectasis
- Reduces QV mismatch
- Conserves surfactant
Causes lung expansion during apnea
- Assists alveolar recruitment
- Increases respiratory drive

Nasal PPV Complications
Trauma
Leak
NIPPV vs. NCPAP

Cochrane Review, 2014

- Preterm infants after extubation
- NIPPV reduces extubation failure
- Device and synchronization may be important variables

NIPPV vs. NCPAP

Newborn Infants

GA 30-33 wk/7 weeks

Randomized to NIPPV or NCPAP after extubation

- No difference in death or BPD
- But...
  - No standardization of NIPPV practice

NIPPV intervention not well defined

NIPPV vs. NCPAP

200 Preterm Infants

GA 26-33 wk/6 weeks

Randomized to NIPPV or NCPAP

No difference in BPD

NIPPV Group:

- Fewer failures 24-72hrs
- Fewer failures for babies >1000g

But...

- NIPPV rate was 20-30; too low for smaller babies
- NIPPV weaned to NCPAP after 72hrs

INSURE

Verder, et al

- 1994: 68 infants on NCPAP, GA 25-35 weeks
- Reduced INSURE need for MV: 35% vs. 64% (p=0.001)
- 1999: 60 infants with RDS on NCPAP, GA <30 weeks
- Earlier INSURE improved oxygenation and reduced IM/Death and MV

INSURE

Intubate
Surfactant
Extubate

Neurally Adjusted Ventilatory Assist