Non-Invasive Respiratory Support in the NICU
Outline

• Who needs support?
  • Oxygenation problems
  • Ventilation problems
  • Apnea

• Modes of support
  • Nasal cannula
  • High Flow Nasal Cannula (HFNC)
  • Continuous Positive Airway Pressure (CPAP)
  • Nasal Intermittent Positive Pressure Ventilation (NIPPV)
  • Neurally Adjusted Ventilation Assist (NAVA)*
How do we know a baby needs support?

- Low oxygen saturations
- Increased work of breathing
- Apnea
- Abnormal Blood Gas
  - pH
  - pCO$_2$
  - pO$_2$
  - Bicarbonate/Base
An Aside on Blood Gases

Textbook Goal Ranges:

- pH: 7.35-7.45
- pCO$_2$: 35-45 mmHg
- pO$_2$: depends on gas sample
  - Arterial: 80-100 mmHg
- Bicarb: 22-26 mEq/L
- Base: -2 to +2

But are these goals the same for every NICU baby?

- Extremely preterm infant with severe RDS?
- Preterm infant with persistent oligohydramnios and pulmonary hypoplasia?
- Term infant with meconium aspiration and pulmonary hypertension?
- Infant with congenital cardiac disease?
Benefits of Non-Invasive Support

- Less airway trauma
- Less airway inflammation
- Less chronic lung disease
- Less infections
- Easier for parents to hold/bond and for medical team to perform cares
- Less expensive
- Still provides PEEP to maintain FRC*
- May allow infants to work on oral feeding*

* Not true for all modes
Nasal Cannula

• Provides flow from 0-2LPM via nasal prongs
  • If liter flow is too high without associated heat and humidity, nasal trauma can ensue.

• Can blend oxygen concentration

• Does not provide PEEP to establish or maintain FRC
  • Safe to orally feed
HFNC

- Technically:
  - Heated and humidified to prevent mucosal injury
  - Can deliver 2-8 LPM to neonates via nasal prongs
  - Can blend oxygen concentration

- Physiologically:
  - Saves energy when air is delivered heated and humidified, rather than body needing to perform these tasks
  - Heat and humidity improve laminar flow
  - Provides positive distending pressure at flows ≥ 2 LPM
  - Dependent on leak around prongs in nares and loss of flow through the mouth and down the GI tract
  - Eliminates nasopharyngeal dead space, leading to improved gas exchange
HFNC

• Benefits:
  • Decreased work of breathing
  • Reduced supplemental oxygen requirement
  • Similar outcomes to CPAP in terms of CLD and death with HFNC as initial support and with HFNC as post-extubation support
  • When weaning non-invasive support, infants using HFNC as an intermediate step had shorter hospital stays
  • Slightly decreased risk of pneumothorax with HFNC compared to CPAP

• Disadvantages:
  • No way to truly measure level of flow
  • Leak around prongs decreases pressure delivered
  • Can get nasal trauma, but less so than CPAP

Cochrane meta-analysis, 2016
CPAP

• Technically:
  • Provides positive pressure throughout the respiratory cycle to spontaneously breathing infants via nasal prongs or mask
  • Can blend oxygen concentration

• Physiologically:
  • Prevents alveolar collapse
  • Increases and maintains FRC
  • Improves lung compliance
  • Splints the airways open
  • Stabilizes the chest wall
  • Stimulates lung growth
  • Bubble CPAP provides oscillatory effect
  • Lose some distending pressure out mouth and into GI tract, like HFNC
CPAP

- **Benefits:**
  - Treats apnea (obstructive)
  - Reduces CLD as compared to intubation
  - In comparison to prophylactic or early surfactant, CPAP decreases the need for and duration of invasive mechanical ventilation and decreases the rate of postnatal corticosteroids to treat BPD (SUPPORT Trial, 2010)
    - Infants born between 24 0/7 – 25 6/7 weeks showed lower mortality in the CPAP group

- **Safety:**
  - Watch for nasal trauma
  - Gastric distention
  - Air leak can occur
  - Don’t use with upper airway abnormalities and GI conditions that would worsen with increased abdominal pressure
NIPPV

- Technically:
  - Uses a ventilator to provide intermittent breaths through nasal prongs or mask
  - Set a PIP, PEEP, rate, iTime
    - Higher PIP, PEEP, iTime because of leak
    - May need lower rate if not synchronized
  - Alone, this is NOT synchronized

- Physiologically:
  - Maintains patency of alveoli with positive pressure (like CPAP)
  - Triggers augmented inspiratory reflex (Head’s paradoxical reflex)
  - Doesn’t always deliver pressure against a closed glottis
NIPPV

• Benefits
  • Less inflammation than mechanical ventilation
  • Decreases risk of failing extubation and decreased rate of air leaks compared to CPAP
  • No change in CLD or death compared to CPAP
  • When synchronized, may decrease WOB, increase TV, decrease CO2 compared to CPAP

• Safety
  • Watch for nasal and/or septal breakdown
  • No increase in intestinal perforation, NEC, feeding intolerance

1Cochrane meta-analysis, 2017
NAVA

- Neurally Adjusted Ventilatory Assist
- Can be used on any patient requiring ventilatory assistance with an intact electrical signal from the brain to the diaphragm and in whom an NG can be placed
  - Phrenic nerve innervates the diaphragm, and is formed from spinal roots C3-C5
- Technically:
  - Delivers assistance proportional to and in synchrony with the patient’s respiratory efforts, as determined by the Edi signal
  - Edi signal: the electrical activity of the diaphragm
  - Edi catheter: special NG tube with a series of electrodes
NAVA

Technically:

• When the preset Edi trigger level is reached, the ventilator assists the breath in proportion to the Edi signal.

• The pressure the vent delivers is:
  • NAVA level x (Edi signal - Edi min) + PEEP
  • NAVA level is how much work of breathing the vent will take over from the patient

• When the Edi signal falls to 70% of its peak value, the vent stops assisting, so the patient can exhale

Higher electrical impulses will be generated to overcome weaker respirations and decreased spontaneous respiratory rates, so Edi signals with higher voltage in sicker patients
NAVA

• How to Order NAVA:
  • Set a NAVA level
  • Set back up ventilation just like you would NIPPV: PC/PS, PEEP, Rate

• Benefits:
  • Synchronized support
  • Objective criteria for weaning support
    • As the Edi signal is lower (which happens as the patient improves), less support is being delivered without you doing anything.
  • Objective criteria for increasing support
    • If NAVA level is decreased and the Edi signal disproportionately rises, then the patient wasn’t ready to wean.

• Safety:
  • Automatically switches to back up mode (essentially NIPPV without synchronization) in the case of apnea or Edi catheter dislodgement
High Frequency Nasal Oscillatory Ventilation

- Being used in some European centers
- Most frequently used for premature infants <1500 gm who failed nasal CPAP
- Median settings were mean airway pressure of 8 (6-12) with frequency of 10 (6-13).
- Complications include abdominal distention, upper airway obstruction due to secretions, viscous secretions.
References


Diblasi RM. Nasal continuous positive airway pressure (CPAP) for the respiratory care of the newborn infant. *Respir Care*. 2009. 54(9):1209-35.


