Non-Invasive Respiratory Support in the NICU

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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 $\geq$ 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

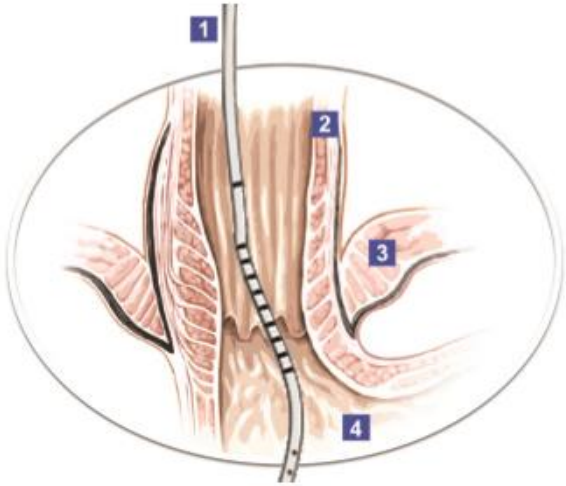
NIPPV

- 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

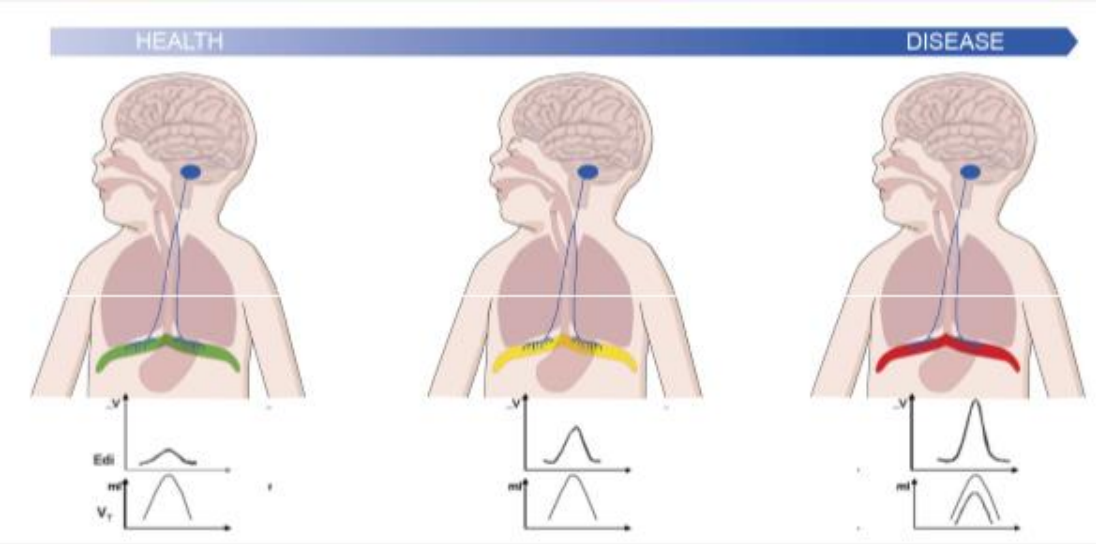
[1]Cochrane meta-analysis, 2017

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



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

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 it's peak value, the vent stops assisting, so the patient can exhale

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

Coming Next . . .

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

Cummings JJ, Polin RA, AAP the Committee on Fetus and Newborn. Noninvasive respiratory support. *Pediatrics*. 2016;137(1):e20153758.

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

Fischer HS, Bohlin K, Buhrer C, Schmalisch G, Cremer M, Reiss I, Czernik C. Nasal high frequency oscillation ventiolation in neonates: a survey in five European countries. *Eur J Pediatr*. 2015. 174(4):465-71.

Lemyre B, Davis PG, DePaoli AG, Kirpalani H. Nasal intermittent postitive pressure ventilation versus nasal continuous positive airway pressure for preterm neonates after extubation. *Cochrane Database Syst Rev*. 2014. 4(9):CD003212.

Maquet Getinge Group. NAVA® and NIV NAVA in neonatal settings pocket guide. Accessed online 7/29/17 at https://www.maquet.com/globalassets/downloads/products/nava/us/nava-and-niv-nava-neonatal-pocket-guide-en.pdf?lang=en-US&src=/us/search/?query=NAVA.

SUPPORT Study Group of the Eunice Kennedy Shriver NICHD Neonatal Research Network. Early CPAP versus surfactant in extremely preterm infants. *N Engl J Med*. 2010. 362: 1970-1979.

Wilkinson D, Andersen C, O'Donnell CP, De Paoli AG, Manley BJ. High flow nasal cannula for respiratory support in preterm infants. *Cochrane Database Syst Rev*. 2016. 22(2):CD006405.