Implementing Heated High-Humidity High-Flow Nasal Cannula in Non-Intensive Care Settings

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Disclosures

Speaker	Disclosures
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Lisa Robinson, MSN, RNC-MNN, CPN, RN	No disclosures
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Learning Outcome

- The primary purpose of this presentation is to discuss the challenges of implementing Heated High Humidity High Flow Nasal Cannula (HFNC) in the general pediatric acute care setting. The basic concepts of HFNC use and a review of the pediatric pulmonary system as it relates to HFNC use will also be discussed.

HFNC: Outline

- Discuss basic concepts in HFNC therapy
  - What is HFNC
  - How does HFNC work
  - Why use HFNC
- Discuss nursing implications for HFNC
  - Review of pediatric pulmonary system
  - Daily care and ADL's
  - Device specific knowledge
- Identify practice changes for the implementation of HFNC
- Discuss lessons learned
  - Challenges
  - Outcomes

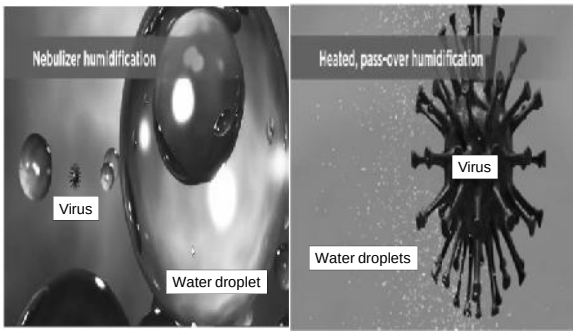
What is HFNC

- **H**eated **H**igh **H**umidity **H**igh Flow Nasal Cannula
  - **Heated**: 34-37 C
  - **Humidified:** 100%
- Non-invasive positive pressure support
- Flow delivered is generally greater than the patient's inspiratory flow
  - Greater than 2 L/min

Device Comparison

	Simple Nasal Cannula	CPAP	HFNC
Heat	• Room air • 20 C	• Room air • 20 C	• Body temperature • 34-37 C
Humidity	• Less than 50% • Droplet (bigger)	• Minimal • Droplet	• Nearly 100% • Vapor (smaller)
Oxygen	• Limited to <50% • 1-4 L/min	• Up to 100% • Flow and FiO2 not independent	• Up to 100% • Independently titrated from flow • 2-30 L/min
PEEP	• Not a closed system • Limited by intolerance of flow rates	• Closed system • Constant	• Not a closed system • Variable
Impact	• Does not require ICU • Easy to set up • Minimal impact on ADL's	• Requires ICU • Not well tolerated • Impacts ADL's	• Does not require ICU • Easy to set up • Minimal impact on ADL's

Droplet vs. Vapor Humidification



Why Use HFNC

Superior **Heat** and **Humidity**

34-37 C	100%

Better tolerated

Higher flow rates	Better airway conductance

Avoids Intubation

Risk	Higher LOC	Cost

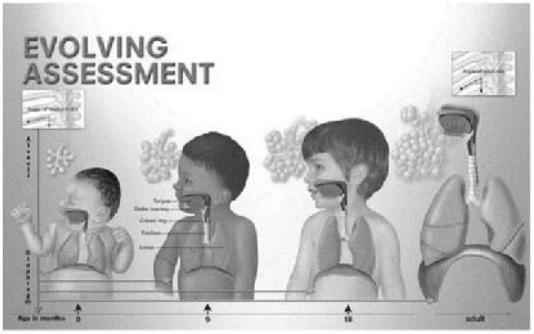
Why Does HFNC Work?

- Superior **heat** and **humidity**
  - Promotes oxygenation and ventilation by under-developed respiratory structures
  - Prevents inherent broncho-spastic defense mechanism
  - Improves thinning of mucous production associated with pediatric respiratory illnesses

Indications for Use

- No evidence based guidelines exist
- Restricted to **mild-moderate respiratory distress**
  - Viral Bronchiolitis
  - Pneumonia
  - Influenza
  - Asthma
- Must have effective
  - Spontaneous respiratory effort
  - CO2 elimination

Review of Pediatric Anatomy



Pediatric Considerations

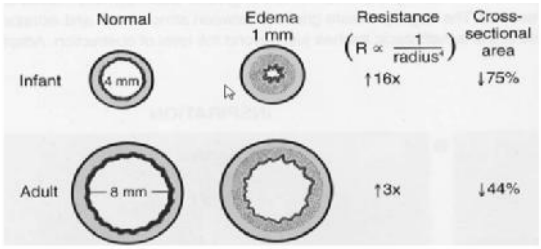
- Higher metabolic demand
- Higher oxygen requirements
- Relatively large head, tongue
- Relatively small, narrow airway structures
- Respiratory muscles are poorly developed
- Abdomen is relatively large

Pulmonary Defense Mechanisms

Pulmonary Structure	Mechanism of Defense
Mucosa of upper respiratory tract	• **Warm and humidify** inspired air • Trap and remove particles/gas from inspired air
Nasal hairs/turbinates	• Trap and remove particles/gas from inspired air
Mucosal blanket	• Traps foreign particles / bacteria in lower airways
Irritant receptors in nares	• Sneeze reflex removes chemical/mechanical irritants
Irritant receptors in oropharynx, trachea, larger airways	• **Cough reflex (bronchospasm)** responds to chemical/mechanical irritants
Cilia	• Propel mucosal blanket & entrapped particles toward oropharynx: swallowed or expectorated
Alveolar macrophages	• Ingest & remove foreign particles/bacteria from alveoli by phagocytosis

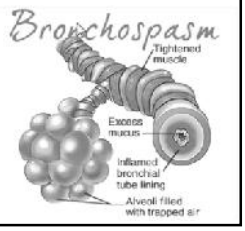
Heuther, S. & McCance, K. *Understanding Pathophysiology, 5th Ed.*

Airway edema and **mucous secretion** have profound effects on airway patency and resistance to air flow



Bronchospasms

- The body does not like **COLD, DRY** air
- Bronchospasm
  - Protective mechanism
  - Limits insufficiently conditioned air to be inspired
  - Immediate
- Results in
  - Airway constriction
  - Increased mucosal swelling
  - Increased secretions

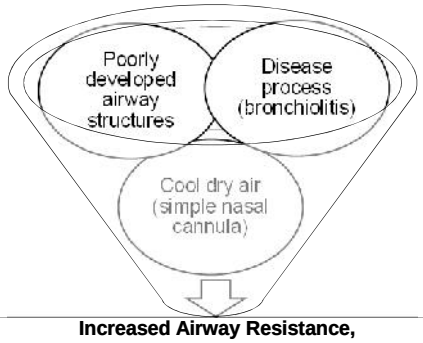


Bronchiolitis

- Most common reason WORLDWIDE that children less than one year of age are admitted to the hospital
- Costs approximately US$1.73 billion each year
  - Significant PICU burden
- There is no specific treatment for bronchiolitis
  - Hydration
  - Respiratory support
- Historically escalation of oxygen therapy has been

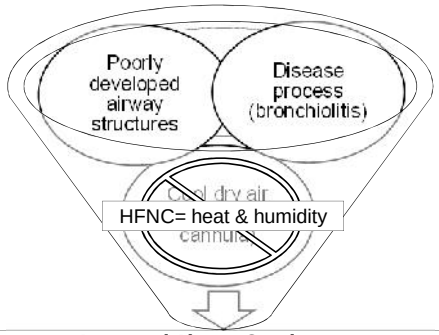
  Simple NC > CPAP> Intubation

In Summary



Increased Airway Resistance, Increased Airway Obstruction

With HFNC…



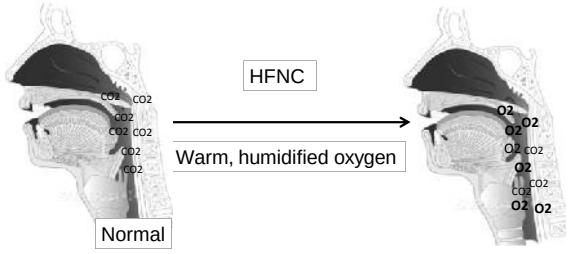
Improved Airway Conductance Minimal Obstruction

How Does HFNC Work?

1. Washout of nasopharyngeal (NP) dead-space
2. Decreases NP airway resistance (work of breathing) by providing adequate flow
3. Improves mechanics of respiration by supplying adequately warmed and humidified air
4. Reduces metabolic demand required by the body to heat and humidify air
5. Provides distending pressure that is transmitted to the lung parenchyma (PEEP)

Nasopharyngeal Washout

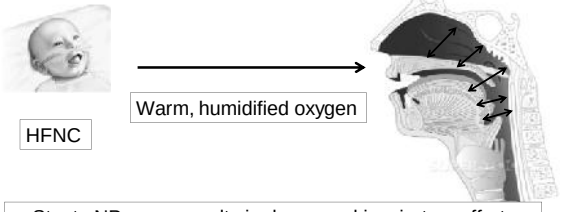
- FiO_2 replaces residual CO_2 from exhalation with O_2



The amount of O_2 rich air inhaled is increased

Nasopharyngeal Resistance (Inspiratory)

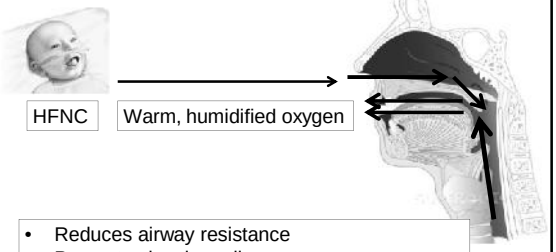
- Superior **heat** and **humidity**
  - Eliminates reflexive bronchospasm
  - Diminish the resistance in the nasal mucosa
  - Increased gas flows better tolerated



- Stents NP open; results in decreased inspiratory effort
- Pharyngeal pressure± 6 cm H_20

Nasopharyngeal Resistance (Expiratory)

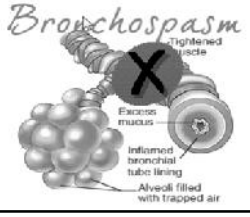
- Inspiratory flow exits the mouth
  - May entrain exhaled air
  - Minimizes air trapping in the alveoli



- Reduces airway resistance
- Prevents alveolar collapse
- Facilitates air elimination (CO_2) from the lungs

Improved Conductance and Compliance

- Superior **heat** and **humidity**
  - Avoids reflexive bronchospasm
  - Improves muco-ciliary function
  - Decreases viscosity of secretions
  - Decreases airway edema
  - Prevents atelectasis

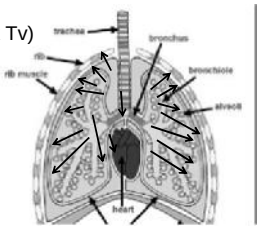


Improved Energy Expenditure

- Superior **heat** and **humidity**
  - Decreases metabolic demand
  - It takes calories (= work) to warm inspired air to body temp and humidify
  - Infants inherently have higher metabolic demand

Positive End Expiratory Pressure (PEEP)

- Increased flow rates provide **positive distending pressure**
- Not consistent; combination of
  - Flow (L/min)
  - Patients minute volume (RR x Tv)
  - Mouth open or closed
  - Delivery system type



When HFNC Works

- Improved inspiratory flow
  - No bronchospasm
  - Prevents pharyngeal collapse
  - Prevents small airway collapse
  - Decreases effort required of diaphragm
- Improved gas exchange at the alveolar level
- Decreased respiratory effort
- Decreased respiratory rate

Advantage of HFNC

- Primary benefit is it can avoid intubation
- Intubation associated risks
  - Decreased muco-ciliary clearance
  - Infection
    - Bypass of the immune barrier function of the airway
    - Ventilator associated pneumonia (VAP)
  - Trauma to the airway
    - Ventilator induced lung injury (VILI)
  - Sedation

Other Advantages of HFNC

- More comfortable, better tolerated than other devices
- Easy to setup
- Fewer skin lesions
- Minimal impact on ADL's
- Can be managed outside of the PICU: $$$
- Better heat and humidity delivery
- Better titration of FiO_2

Disadvantages of HFNC

- Less effective pressure delivery; not a closed system
- May delay intubation in sicker patients
- Risk for gastric distension
- Mucosal membrane and skin breakdown
- Tolerance in young children
- Noisy
- Cost compared to simple cannula
- Does not impact LOS

http://onlinelibrary.wiley.com/doi/10.1111/iwj.12135/pdf

Side Effects of HFNC

- Air leaks
  - Pneumothorax
  - Pneumo-mediastinum
  - Pneumo-pericardium
  - Pulmonary interstitial emphysema
- Erythema/erosion of the nasal mucosa or septum
- Abdominal distension
- Barotrauma

Contraindications for Use

- Collapsed lung or Pneumothorax
- Facial trauma
- Basilar skull fracture
- Recent facial surgical procedure
- Patient who is severely lethargic or unable to maintain a patent airway
- Critical respiratory acidosis

Factors That Affect Efficacy

- Size of the child
- Mouth leaks: use pacifier to minimize leak
- Nare to prong ratio
- Comorbidities: Cardiac, Chronic Lung Disease
- Co-infections: are bad!
- Device used: Fischer- Paykel vs. Vapotherm
- Fevers that may transiently increase work of breathing

Impact of Fever on Respiratory Effort

- A fever will transiently
  - Increase metabolic demand
  - Increase respiratory rate
  - Increase heart rate
- A febrile child may appear to be in respiratory distress
- Treat the fever!
- Consider impact of fever on respiratory effort when initiating or titrating HFNC

Non-Responders

- Most kids who fail initiation of HFNC had
  - Less tachypnea (fatigue)
  - No change in respiratory rate on initiation
  - No change or increase in heart rate within 60 minutes of initiation
  - Hypercarbia/respiratory acidosis (higher PCO2)
  - Persistent desaturations following the initiation of therapy

RN Role: Assessment and Monitoring

- Assessment
  - Respiratory status: PEWS
  - Skin
  - Vital signs
- Monitoring
  - Response to titration: PEWS
  - Equipment
    - Fit of cannula
      - Prongs should fill 50% of the nares diameter
    - Humidification bag
    - Tubing
    - Temperature of the device

RN Role: Continuity of Care

- Documentation
  - Setting changes: L/min flow and FiO_2
  - Patient response to therapy: PEWS
- Communication
  - Changes in status & PEWS score
  - Coordinate with MD's and RT
- Titration
  - Adjust FiO_2 to meet SpO_2 parameters
  - Adjust LPM Flow per MD order: based on Respiratory Score (PAS)

FiO_2 versus Flow

- FiO_2 (O_2 %)
  - Goal is to maintain desired SpO_2
    - ≥ 92-94%
    - Cardiac babies may be lower
  - RN driven
- Flow (L/min)
  - Treats respiratory effort
  - Weaned based on PAS
    - Breath sounds
    - Respiratory rate
    - Retractions
  - RT/MD driven

RN Role: ADL's

- ADL's
  - Encourage quiet play as tolerated
    - Blowing bubbles
    - Arts & crafts
  - Can be held, placed in swings, etc.
  - Cannot ambulate far on HFNC
- Diet
  - No data currently to support best feeding practices
  - Dependent on respiratory effort and not L/min flow
    - May be NPO, NG/ND tube fed, PO ad lib

RN Role: Daily Care

- Hygiene:
  - Assess skin every shift and PRN; including the nares
  - Oral care every shift - this is important!!
  - Daily bath
- Suctioning
  - Before all feeds and PRN
- Positioning
  - Use shoulder rolls to maintain neutral head position

Global Challenges

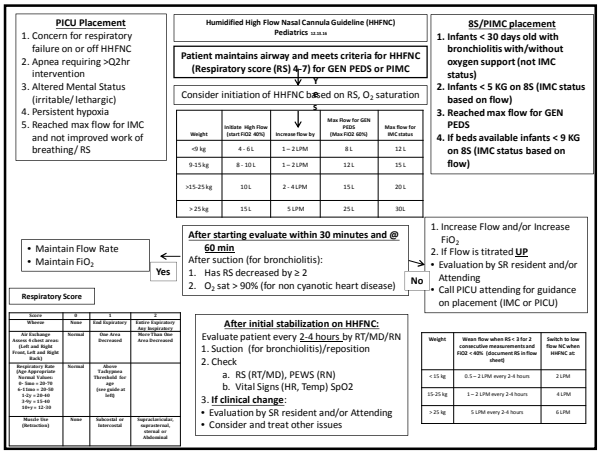
- No valid tool exists to evaluate respiratory status in pediatrics
  - Pediatric Asthma Score (PAS)
  - Pediatric Early Warning Score (PEWS)
- No Evidence Based Practice Guide (EBPG) for HFNC
  - Initiation
    - Which populations
    - How much flow
  - Titration
    - How much
    - How fast
  - Monitoring
    - ICU versus non-ICU setting

Implementation at ICH

- Why HFNC was implemented on the general floor
  - Meet volume needs during bronchiolitis season
  - Decompress PICU volume
- Who was HFNC initiated on
  - Bronchiolitis diagnosis
  - Quickly expanded (Asthma, Pneumonia, many others)
- Timing for Implementation
  - PAS score ≥ 4
  - Off season (May)
    - Low bronchiolitis volumes
    - Prior to July resident on-boarding

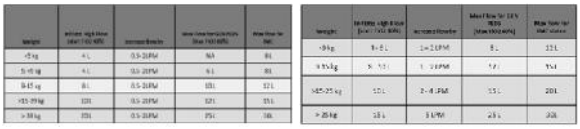
Implementation at ICH (cont.)

- Where: All units depending on initiation rates
  - PED
  - PICU
  - PIMC
  - PMS
- What rates
  - Flow
    - 0.5-1 L/kg/min
    - Quickly increased to 1-1.5 L/kg/min
  - FiO2
    - 40% O2



Changes in Flow Rates

Initial **Post-Implementation**



Challenges Specific to ICH

- Staff education
  - RN vs. RT vs. MD competency varied
  - Resistance to use
  - Misconception that HFNC is simple NC cranked up
  - Most patients were started on 4L/ 40% regardless of weight
- Variation in tools used to monitor
  - PEWS (RN) vs. PAS (RT and MD)
  - Scoring criteria and tools vary between system-wide hospitals

Challenges at ICH: Transfers

- Initiating in Pediatric Emergency Department (PED)
  - Commits to admission
  - Increased through-put time
  - Bed placement
- Fevers
  - Resulted in unnecessary transfer to higher LOC
- Cannot transport HFNC equipment
  - Transported on simple NC at same flow rates
  - Decompensation during PED transfer to floor
    - Bronchospasm is immediate

More ICH Challenges

- Communication
  - RN-RT-MD triad is cumbersome
  - Change of shift
- Documentation
  - Initiation/titration done on clinical judgment not PAS score
  - PAS scores not recorded in EPIC
  - Changes in flow rates not recorded in EPIC
- Outcomes monitoring (LOS, transfers, cost)
  - Limited resources
  - New hospital build; increased bed capacity skewed data

Ongoing Research: EBPG

- There is very little data and no EBPG for
  - When to initiate HFNC
  - Where to start HFNC
  - Which populations to use HFNC on
  - How to titrate HFNC
  - Tools to monitor response
  - Safety and efficacy
  - Method of nutritional support

Ongoing Research: Outcomes

- Impact on
  - LOS
  - PICU transfers
  - Cost
  - Safety and efficacy in delivery
  - Efficacy of delivering inhaled medications

HFNC Tidbits

- At ICH HFNC is first step of O_2 delivery
  - Future of simple nasal cannula may be limited
- Acceptance of use was slow initially
- No evidence that HFNC improves distribution of inhaled treatments
- Respiratory rate and SpO_2 improve initially
- Retractions generally did not initially improve
- Sicker children are more likely to fail
- LOS is not reduced
- HFNC does not shorten the course of the underlying viral illness

Terminology

- ADL: Activities of daily living
- EPBG: Evidence based practice guidelines
- HFNC: High flow high humidity nasal cannula
- LOC: Level of care
- LOS: Length of Stay
- LPM: Liter per minute (flow)
- MD: Physician
- NC: Simple nasal cannula
- NG/ND: Nasogastric tube, nasoduodenal tube
- NP: Nasopharynx
- NPO: Nothing by mouth
- PAS: Pediatric Asthma Score
- PEWS: Pediatric Early Warning Score
- PED: Pediatric Emergency Department
- PEEP: Positive End Expiratory Pressure
- PICU: Pediatric Intensive Care Unit
- PO: By mouth
- RR: Respiratory rate
- RT: Respiratory Therapist
- Tv: Tidal volume

Questions?

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