High Flow Therapy
An Alternative Form of Non-invasive Respiratory Support

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Nasal Application

- Adult
  - 5-60 LPM
- Pediatric
  - 5-25 LPM
- Neonate/Infant
  - 1-8 LPM
How does it work?

• Flow support
  – High flow readily available in the oro-nasopharynx
    • Oxygenation and CO2 washout
  – No need for reservoir
  – Reduce WOB

• Heat and Humidity

• Expiratory distending pressures
  – CPAP effect on exhalation
  – May splint airways and improve FRC
Mechanisms of action for high flow therapy (HFT)

The use of high flow therapy (HFT) devices in clinical settings is rapidly growing. These devices are being applied to patients across age groups in a variety of disease conditions. The mechanisms through which HFT devices affect the respiratory system and alter gas exchange are still under investigation but a growing body of evidence is supporting the mechanisms of action for HFT to be five-fold.

1) HFT provides for washout of nasopharyngeal dead space, which contributes to establishing improved fraction of alveolar gases with respect to carbon dioxide as well as oxygen.¹

2) The distensibility of the nasopharynx provides significant resistance on inspiratory relative to expiratory efforts.² HFT provides adequate flow rates to match inspiratory flow and thus markedly attenuates the inspiratory resistance associated with the nasopharynx, and thus eliminates related work of breathing.

3) The provision of adequately warmed and humidified gas to the conducting Airways improves conductance and pulmonary compliance compared to dry, cooler gas.³

4) The provision of adequately warmed and humidified gas through the nasal pharynx reduces the metabolic work associated with gas conditioning.

5) High flow through the nasopharynx can be titrated to provide positive distending pressure for lung recruitment.⁴
- **Washout of CO2 anatomical dead space**

- **Thoracoabdominal synchrony with lower RR**
  - Itagaki T, et.al. Effect of high-flow nasal cannula on thoraco-abdominal synchrony in adult critically ill patients. Respir Care. 2014;59:70-4

- **Decrease in resistive work of breathing**

- **COPD patients had greater exercise capacity**
The three layers of the mucociliary transport system are compromised, which decreases or stops mucus clearance as a result of:

- The mucus layer becoming thick and tenacious
- The thickness of the aqueous layer decreasing, causing cilia to slow down or stop
- Heat loss from the epithelium cells, making cilia beat less frequently.

Adapted from Williams et al. (1996)
Humidification

- Lack of humidification can affect:
  - Pulmonary compliance
  - Conductance

Positive distending pressure?

Flow on inspiration is converted to pressure on expiration.
Collapse lung

Inspiratory phase

Expiratory phase

Humidified

HIGH

FLOW

Support

DISTENDING

PRESSURE

For

Exp resistance
Positive distending pressure

- Electrical lung impedance tomography
  - Significant increase in end-expiratory lung impedance and airway pressure
  - Greater end-expiratory lung volume

- A degree of CPAP generated with the HFNC therapy

- Pulmonary distending pressure and alveolar recruitment,…unclear affects lung volume.
Eliminating energy expenditure

- The increase in evaporative water loss through the skin and respiratory tract consumes a substantial amount of heat energy in the form of latent heat of evaporation, and the increase in muscle activity caused by increased respiratory rate and the discomfort resulting from overheating also increases metabolic rate.

  - T F Fok, J-S Gu, C N Lim, P C Ng, H L Wong, K W So. Oxygen consumption and resting energy expenditure during phototherapy in full term and preterm newborn infants. Arch Dis Child Fetal Neonatal Ed 2001;85:F49–F52
How to apply HFT?

• Flow
  – Must meet or exceed patient’s inspiratory demands
  – The higher the flow
    • More airway flush
      – CO2 washout
      – Decrease WOB
    • Reduced airway resistance
      – Flow Support
    • More PDP
      – Increased flow penetration for improved FRC
How to apply HFT?

• Titrate FiO2
  – Titration of FiO2 to maintain acceptable SpO2
  – Continue to increase FLOW if FiO2 remains greater than .60
  • FiO2 remains greater than .60 despite increased flow
    – Intrapulmonary shunting present, initiate lung expansion therapies, i.e. IPV or Metaneb
    – Initiate airway clearance systems, i.e. Vest Therapy
VILI

Mechanical Ventilation

Biochemical Injury
- cytokines, complement, prostanooids, leukotrienes, reactive oxygen species, proteases

Biophysical Injury
- shear
- overdistention
- cyclic stretch
- intrathoracic pressure ↑

Distal Organs
- tissue injury secondary to inflammatory mediators/cells
- impaired oxygen delivery
- bacteremia

→ MSOF

Macklin and Macklin in 1944

HFT Devices

- Vapotherm
  - Stand alone unit
  - Transport Unit
  - Heliox
HFT Devices

- Fisher & Paykel Optiflow
  - MR 850
    - HFNC
    - Trach application
  - Max Venturi vs Blender
HFT Devices

- Hudson Teleflex
  - Comfort Flow
  - HFNC
Transport HFT

- NeoPodT
  - Transport Humidification System
    - HFNC
    - Valve CPAP
    - Ventilator
HFT Devices

- Fisher & Paykel
  - Airvo 2
  - HFNC
    - Humidification
    - Minimal airway flush
    - Minimal or No PDP
  - Trach application
Neonatal Application

- CLD
- Prevalence
  - 60,000 born/yr in the US
    - <30wks/<1,500g
    - 20% develops BPD
- Cost of care
  - NICU care
    - Estimated $2.3 billion due to RDS
  - First 2 years
    - Infections
      - 90% RSV
    - Family burden
    - Long term care
      - Asthma-like symptoms
Pathogenesis of BPD

- Intubation
  - Endotrauma
  - Biotrauma
  - Colonization, infection
    - Inflammation
      - BPD

- M. ventilation
  - Barotrauma
  - Volutrauma
  - Ateletrauma
Evidence-based practices

Antenatal steroid

Prophylactic surfactant (L&D)

Neopuff-blender/pulse oximetry (L&D)

HFOV

HFT

nCPAP

HFT

CMV

HFT

Nasal cannula/Room air
Strategy for Respiratory Support in ELGA Infants

GA 23 – 26 wk

HFOV x 3-5 days
nHFOV x 3-5 days
Servoi NAVA

No Apnea多半

Extubate多半

NIV NAVA HFT

Recurrent Apneas多半

Continue SIMV
Until Apneas Stop

NIV – NAVA
Extubate to HFT
Why the urge to extubate?

- Effectively ventilates without an ET tube
  - Colonization of trachea with bacteria occurs in 80% of intubated infants…bacteria will ignite the inflammatory process, which can lead to lung injury.
  - NIPPV…Enhance the practice of early extubation…
  - In premature infants, there is a strong association between MV and brain injury.
  - For ELBW infants, each 10 days of MV was associated with a 20% increased risk of cerebral palsy.


- Effective stimulant
  - By initiating inspiratory reflexes, the respiratory drive is activated… Peter de Winter J et al, Noninvasive respiratory support in newborns. Eur J Pediatrics. 2010
nCPAP

- Remains the Gold Standard
- Different systems
  - Bubble nCPAP
  - Flow generators
  - Ventilator
    - nCPAP
    - NIPPV
      - NIV
      - BiPAP
- High demand
  - Widespread use
  - Prevent extubation failure, AOP, RDS
  - Improved outcomes
  - Decreased BPD rates
    - Is chronic lung disease in LBWI preventable? Avery ME et al Pediatrics 1987
Risk associated with nCPAP

- Nose deformation/Nasal septum damage
- Head deformation
- Crusting of the mucosa
- Nasal bleeding/infection
- Limited mobility/limits kangaroo care
- Infant stress
- Seal/Pressure
- CPAP Belly
- Air leak/ Pneumothorax
- Set up
  - Depth of water seal
    - Inconsistent
  - Inaccurate taping
  - Off label
HFT in the NICU

Humidity is vital.

Courtesy: Fisher & Paykel
Humidity is vital
Supporting evidence

  - Compare HHFNC vs standard NC (randomized)
  - 30 infants in two groups (15)
  - randomized, prospective, masked, crossover trial
  - Vapotherm performed better than a standard HFNC in maintaining normal appearing mucosa, a lower respiratory effort, and averting reintubation, with no recognized complications

  - Compare HHFNC(3,4,5) vs vent nCPAP
  - 18 infants
  - Randomized
  - No difference in WOB, no increase in PDP, HHFNC comparable support to nCPAP
Supporting evidence


Assess usage & safety of HHFNC in two tertiary hospitals
- Two groups
  - Frequency of usage over nCPAP
  - Compare outcomes between modalities
- Retrospective
- Utilization of HHFNC increased & nCPAP decreased; vent days decreased
- No differences in death, vent-days, BPD, blood infections, etc.
- More infants intubated failing CPAP vs HHFNC
- Overall, no apparent differences in outcome
Recent evidence


Safety and Long Term Outcomes with High Flow Nasal Cannula Therapy in Neonatology: A Large Retrospective Cohort Study

Abstract

Objective: High flow nasal cannula therapy (HFT) has been shown to be similar to nasal continuous positive airway pressure (nCPAP) in neonates with respect to avoiding intubation. The objective of the current study is to determine if there are trends for adverse safety and long-term respiratory outcomes in very low birth weight infants (<1500 g) from centers using HFT as their primary mode of non-invasive respiratory support compared to data from the largest neonatal outcomes database (Vermont Oxford Network; VON).

Methods: A multicenter, retrospective analysis of pulmonary outcomes data was performed for the calendar years 2009, 2010 and 2011. Performance of five HFT centers was compared with population outcomes from the VON database. The five HFT centers routinely use flow rates between 4-8 L/min as described by the mechatronic literature. Weighted average percentages from the five HFT centers were calculated, along with the 95% confidence intervals (CI) to allow for comparison to the VON means.

Results: Patient characteristics between the HFT centers and the VON were not different in any meaningful way, despite the HFT having a greater percentage of smaller infants. The average VON center primarily used nCPAP (69% of all infants) whereas the HFT centers primarily used HFT (73%). A lesser percentage of VLBW infants in the HFT cohort experienced mortality and nosocomial infection. Compared to VON data, an appreciably lesser percent of the HFT cohort were receiving oxygen at 36 weeks and less went home on oxygen.

Conclusions: Considering there was no trend for adverse events, and there was a trend for better outcomes pertaining to long-term oxygen use, these data support claims of safety for HFT as a routine respiratory management strategy in the NICU.
Pre & Post Mechanical Ventilation Guideline

- Hypoxemia, tachypnea, retraction, mild apnea & bradycardia
- Vapotherm- 5-6 LPM, FiO₂ to maintain SpO₂- 85%- 92%
- Wean FiO₂ to .30 to maintain SpO₂ (8-12 hr)
- Gradual flowrate wean by 0.5-1 LPM every 8-12 hr to maintain SpO₂ and stable RR
- If weaning not tolerated, return to previous settings
- At 1-2 LPM, consider bubble jet nasal cannula

No clinical improvement?
- 5-6 LPM not tolerated
- Gradual FiO₂ & flowrate increase by 1 LPM to 8 LPM (max)
- No improvement after 2-4 hr, consider nCPAP or intubation
Risk associated with HFT

- Unregulated pressures
  - High-flow nasal cannula as a device to provide continuous positive airway pressure in infants. K L Spence1, D Murphy1, C Kilian1, R McGonigle1 and R A Kilani2. Journal of Perinatology (2007) 27, 772–775; doi:10.1038/sj.jp.7211828; published online 30 August 2007
Recommendations

• Prongs sizing
  – Outer diameter of nasal cannula prongs must be less than half of the inner diameter of the nares.
  – DO NOT use nose sealing device i.e. Cannulaide or Neoseal, during HFNC applications.
  – DO NOT use chin straps
  – Pacifier use may inadvertently increase airway/lung pressures.
Nasal interface

- Neotech
  - RAM Cannula
  - Bonnet-less nasal cannula
  - Various sizes
  - No need for tight fitting prongs
  - Works well for NIPPV and CPAP applications
  - Caution during HFT due to large prongs
Is skin protection necessary?

- Institutional based protocol
- Discouraged
  - Build up of unregulated pressures during HFNC
  - Unrecognized potential breakdown masked by barrier
- Effective for nasal CPAP and NIPPV applications
The following are compilation of data collected at random on three separate tests:

<table>
<thead>
<tr>
<th>Weight (grams)</th>
<th>nCPAP (cmH$_2$O)</th>
<th>Vapotherm (LPM)</th>
<th>Pressures</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Insp</td>
</tr>
<tr>
<td>1190</td>
<td>+5</td>
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</tr>
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<td>890</td>
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<td>2200</td>
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<td>+2</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Grunt</td>
</tr>
<tr>
<td>1300</td>
<td>6 LPM</td>
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<tr>
<td>980</td>
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<tr>
<td>1200</td>
<td>4 LPM</td>
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<td>+3</td>
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<tr>
<td></td>
<td>8 LPM</td>
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<td>+2</td>
</tr>
<tr>
<td>2300</td>
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<td>+1</td>
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<tr>
<td></td>
<td>8 LPM</td>
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<td>+3</td>
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<td>+5</td>
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<tr>
<td></td>
<td>8 LPM</td>
<td></td>
<td>+4</td>
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</table>
Unregulated pressure video

https://www.youtube.com/watch?v=x4YsvQLHfdg

https://www.youtube.com/html5
Pressure Safe HFNC

- Pressure Pop-O valve (will not exceed 21cm H2O) – audible pop off
- Comfort Soft Plus elastomeric material
- Color coded sizes: Premature; Infant; Neonatal; and Pediatric
- Connection adaptors: 15mm OD; 15mm ID x 22mm OD
- Configured for Fisher Paykel and TeleFlex/Hudson heated humidification systems
- Flow rates: 7, 8, and 10 LPM
- Latex and DEHP Free
- Westmed, Inc
Adjustable pressure limit HFNC
# CLD Rate

## VLBW 401-1500 grams

(2002-2006)

<table>
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<tr>
<th>Institution</th>
<th>‘02</th>
<th>‘03</th>
<th>‘04</th>
<th>‘05</th>
<th>‘06</th>
</tr>
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<tr>
<td>VON 03</td>
<td>27%</td>
<td>28%</td>
<td>27%</td>
<td>26%</td>
<td>26%</td>
</tr>
<tr>
<td>SBMC</td>
<td>14%</td>
<td>11%</td>
<td>8%</td>
<td>12%</td>
<td>14%</td>
</tr>
</tbody>
</table>

SBMC NICU ranked lowest in CLD rates

HFT Impressions

- Early extubation
  - Reduced risk associated with intubation
- Rescue from NIPPV or CPAP
  - Effective weaning to HFT
- Well tolerated by infants and less invasive than CPAP or NIPPV
- Restore normal function and minimize disruption of the upper airway bypass
  - Disruption of adaptive breathing patterns
- Restore normal oral and swallowing function
- Effective form of providing stimulation to apneic infant
- Reduced risk of diaphragmatic muscle atrophy
- Easy set up and much less invasive
  - Nasal interface
- Encourages kangaroo care- bonding with parents
- Ease of use by clinicians
- Inexpensive
- Less maintenance requiring less workforce
Adult applications

- Mild to moderate hypoxemia
  - Atelectasis
  - Pneumonia
  - COPD with resolved hypercapnea (mild to moderate)
  - CHF/Pulmonary edema
  - Heliox applications
  - Pulmonary fibrosis
  - Hypothermia
  - Transtracheal Augmented Ventilation (Homecare)
  - Sleep disorder
  - End of life

Bill Pruitt, AARC Times, 2004 New Treatment Options With Nasal Cannula
Cahtila et.al. Chest 2004 The Effects Of High Flow Versus Low Flow Oxygen On Exercise In Advanced Obstructive Airways Disease
A nasal Cannula Can Be Used To Treat Obstructive Sleep Apnea, Mc Ginley et. al., Am J Respiratory Critical Care Med 2007
Adult applications
Flo Easy HFNC

- Pop-Off Valve: 40 cmH2O
- Flow Range: <60 L/min
- Temperature Operating Range: 18 to 37° C
- Resistance to Flow @ 40 L/min:
  - Small = 21 cmH2O (2.06 kPa)
  - Medium = 19 cmH2O (1.86 kPa)
  - Large = 17 cmH2O (1.70 kPa)
- Connector: ISO 5656-1, 22 mm Male, Conical
- Latex Free & DEHP Free
- Specifically designed for use with the Fisher & Paykel MR850™ System
# Pressures at different flowrates

<table>
<thead>
<tr>
<th>Flowrates (LPM)</th>
<th>Inspiratory phase (cmH₂O)</th>
<th>Expiratory phase (cmH₂O)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>-2</td>
<td>+4</td>
</tr>
<tr>
<td>20</td>
<td>-1</td>
<td>+6</td>
</tr>
<tr>
<td>30</td>
<td>0</td>
<td>+7</td>
</tr>
<tr>
<td>38 (flush)</td>
<td>0</td>
<td>+9</td>
</tr>
</tbody>
</table>

Normal tidal breathing

38 year old Male
Bicore Pulmonary Monitor; Nasopharyngeal Catheter
High Flow Therapy In The Emergency Department: A Paradigm Shift?

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Rationale: High flow nasal cannula therapy (HFT), utilizing variable FiO2 (21-1.0) and flow (10-40 lpm) is commonly used in the intensive care unit for patients decompensating from acute and/or acute on chronic respiratory failure due to hypoxemia and/or hypoxia with or without hypercarbia. COPD is a common pre-existing condition in these cases. In our institution, the majority of these patients have previously been treated with noninvasive ventilation (NIV). Literature suggests the mechanism of action in HFT serves to “wash out” physiologic deadspace1. Based on the assumption, HFT would appear to offer some benefits of NIV, possibly with better tolerance. We made a decision to expand the use of HFT in the Emergency Center (EC) to assess the practicality of this relatively new therapy.

Methods: Quality Improvement Project, based on a technical assessment of ease of operation, patient comfort, and subjective symptom relief. A Likert Scale (1-5, “1”=“Insufficient”, “3”=“Adequate”, “5”=“Excellent”) was utilized to tabulate scores. Results: 16 patients were assessed during the evaluation period. 50% (n=8) presented with preliminary diagnoses of COPD/CHF. 25% (n=4) presented with acute asthma, and 25% (n=4) presented with acute dyspnea of other origin. Patients were placed on HFT with flow/FiO2 combinations at the discretion of the Respiratory Therapist. 75% (n=12) of the patients treated were admitted to the floor or discharged from the EC; 25% (n=4) required ICU admission. Technical Assessment scores were as follows: “Symptom Relief” = 4.2/5, “Comfort” = 4.2/5, and Clinician-scored “Simplicity” = 3.4/5. Conclusion: HFT was well tolerated, offered symptom relief comparable to other methods, and was judged as easy to operate by clinicians. ED patient flow may have also been positively affected since only 25% of those treated with HFT required ICU admission. This is due to many facilities’ Policy/Procedure precluding floor admissions for those patients on NIV. Time spent in ED may also have been positively affected as well. These endpoints were strictly observational, but appear to warrant further study. Further study of HFT application in lieu of NIV is also indicated.

1 Dysart K et al., Research in high flow therapy: Mechanisms of action, Respiratory Medicine (2009)
Physiologic Effects of High-Flow Nasal Cannula Oxygen in Critical Care Subjects

Frederic Vargas MD PhD, Melanie Saint-Leger MD, Alexandre Boyer MD PhD, Nam H Bai MD, and Gilles Bilben MD PhD

INTRODUCTION: High-flow nasal cannula (HFNC) can deliver heated and humidified gas (up to 100% oxygen) at a maximum flow of 60 L/min via nasal prongs or cannula. The aim of this study was to assess the short-term physiologic effects of HFNC. Inspiratory muscle effort, gas exchange, dyspnea score, and comfort were evaluated. METHODS: Twelve subjects admitted to the ICU for acute hypoxemic respiratory failure were prospectively included. Four study sessions were performed. The first session consisted of oxygen therapy given through a high-Frac non-rebreathing face mask. Recordings were then obtained during periods of HFNC and CPAP at 5 cm H2O in random order, and final measurements were performed during oxygen therapy delivered via a face mask. Each of these 4 periods lasted ~20 min. RESULTS: Hypoapinal pressure signals, breathing pattern, gas exchange, comfort, and dyspnea were measured. Compared with the first session, HFNC reduced inspiratory effort (pressure-time product of 156.0 ± 119.2 vs 194.0 ± 208.4 cm H2O x s/min, P < .01) and breathing frequency (P < .01). No significant differences were observed between HFNC and CPAP for inspiratory effort and breathing frequency. Compared with the first session, PwOBW increased significantly with HFNC (167 ± 157 vs 118 ± 371 mm Hg, P < .01). CPAP produced significantly greater PwOBW improvement than did HFNC. Dyspnea improved with HFNC and CPAP, but this improvement was not significant. Subject comfort was not different across the 4 sessions. CONCLUSIONS: Compared with conventional oxygen therapy, HFNC improved inspiratory effort and oxygenation. In subjects with acute hypoxemic respiratory failure, HFNC is an alternative to conventional oxygen therapy. (ClinicalTrials.gov registration NCT01860952.) Keywords: high-flow nasal cannula; continuous positive airway pressure; oxygen therapy; acute hypoxemic respiratory failure; inspiratory effort. [Respir Care 2015;60(10):1369-1376. © 2015 Daedalus Enterprises]

Introduction

Supplemental oxygen administration is the first-line treatment for acute hypoxemic respiratory failure. Oxygen is usually delivered through a high-Frac non-rebreathing face mask. Travel limitation with conventional oxygen administration is the substantial mismatch between oxygen flow and the patient’s inspiratory flow. The patient’s peak inspiratory flow may vary between 10 and 120 L/min during respiratory failure. An alternative to conventional oxygen therapy has been developed. High-flow nasal cannula (HFNC) is a technique that can deliver heated and humidified gas (up to 100% oxygen) at a maximum flow of 60 L/min via nasal prongs or cannula. Studies have shown that HFNC can generate flow-dependent, low-level positive airway pressure (PAP), reduce airway resistivity.
Use of High-Flow Nasal Cannula for Acute Dyspnea and Hypoxemia in the Emergency Department

Nattapol Rituyanai MD, Jamsak Tucheikuna MD, Nattakan Prapnuekkit MD, and Sathorn Kipinyocho MD

BACKGROUND: Acute dyspnea and hypoxemia are 2 of the most common problems in the emergency rooms. Oxygen therapy is an essential supportive treatment to correct these issues. In this study, we investigated the physiologic effects of high-flow nasal oxygen cannula (HFNC) compared with conventional oxygen therapy (COT) in subjects with acute dyspnea and hypoxemia in the emergency room. METHODS: A prospective randomized comparative study was conducted in the emergency department of a university hospital. Forty subjects were randomized to receive HFNC or COT for 1 h. The primary outcome was level of dyspnea, and secondary outcomes included change in breathing frequency, subject comfort, adverse events, and rate of hospitalization. RESULTS: Common causes of acute dyspnea and hypoxemia were congestive heart failure, asthma exacerbation, COPD exacerbation, and pneumonia. HFNC significantly improved dyspnea (2.8 ± 1.8 vs 3.8 ± 2.3, P = .01) and subject comfort (1.4 ± 1.7 vs 3.7 ± 2.4, P = .01) compared with COT. No statistically significant difference in breathing frequency was found between the 2 groups at the end of the study. HFNC was well tolerated, and no serious adverse events were found. The rate of hospitalization in the HFNC group was lower than in the COT group, but there was no statistically significant difference (66% vs 85%, P = .26). CONCLUSIONS: HFNC improved dyspnea and comfort in subjects presenting with acute dyspnea and hypoxemia in the emergency department. HFNC may benefit patients requiring oxygen therapy in the emergency room. Keywords: high-flow nasal oxygen cannula; oxygen therapy; dyspnea; hypoxemia; emergency room. [Respir Care 2015;60(10):1377–1382. © 2015 Duane Read Enterprises]
High-Flow Nasal Cannula in a Mixed Adult ICU

Kristina A Grant MD, Sarah K Spilman MA, Meghan E Halub MD, Julie A Jackson RRT-ACCS, Keith D Lamb RRT-ACCS, and Sheryl M Sahr MD MSc

BACKGROUND: Humidified, high-flow nasal cannula (HFNC) enables mucociliary clearance, accurate oxygen measurement, precise control of flow, and low-level positive airway pressure. There is sparse information concerning the timing of HFNC on patient outcomes such as incidence of adverse events during hospitalization, ICU stay, and post-ICU stay. METHODS: This is a retrospective analysis of a heterogeneous population of medical and trauma ICU patients who received HFNC therapy in a critical care setting. The study sample included 145 subjects who were admitted to the ICU and received HFNC therapy between March 2012 and February 2014. HFNC was delivered by the Fisher & Paykel Oxyflow system. RESULTS: Of the 145 subjects who received HFNC, 35 (24.1%) received mechanical ventilation before HFNC, 21 (14.5%) received mechanical ventilation after HFNC, and 80 (56.3%) never received mechanical ventilation. Delay to first HFNC was moderately associated with unplanned ICU admission and was strongly correlated with the development of ventilator-associated pneumonia. Subjects with a greater length of time between ICU admission and first use of HFNC experienced significantly longer stays in the ICU and post-ICU periods, even after controlling for adverse events and mechanical ventilation. CONCLUSIONS: Study results provide preliminary evidence that early use of HFNC is beneficial in a medical and trauma ICU population, as it was associated with decreased ICU and post-ICU lengths of stay and reduced incidence of adverse events. This suggests that HFNC should be considered early in the ICU as first-line oxygen therapy. Keywords: high-flow nasal cannula; oxygen therapy; mucociliary clearance; positive airway pressure; mechanical ventilation.

Introduction

Many studies regarding the efficacy of humidified high-flow nasal cannula (HFNC) have been published in the last decade, and it is recognized that HFNC facilitates mucociliary clearance, accurate oxygen flow, and low-level positive airway pressure. HFNC has been used successfully with medical ICU patients, as well as in postoperative cardiac and vascular populations. One study in the trauma literature supported use of early noninvasive ventilation (NIV) in blunt trauma, but much work is yet to be done regarding use of HFNC in trauma patients. Although many studies have focused on the physiological mechanisms and processes of the therapy, very few have explored the timing of initiation, relevance to heterogeneous populations, and general patient outcomes. With the benefits of HFNC demonstrated in certain study populations, it is inconceivable to explore other aspects and outcomes of the therapy. For example, one meta-analysis suggested that NIV led to a significant reduction in intubation rates, as well as reduced ICU stay, for subjects experiencing acute respiratory failure after chest trauma. Another review reported that blunt chest trauma subjects benefited from early initiation of NIV, leading to decreased ICU stay, complications, and mortality. Nevertheless, neither of these studies included HFNC, even though some
Efficacy of High-Flow Nasal Cannula Therapy in Acute Hypoxemic Respiratory Failure: Decreased Use of Mechanical Ventilation

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BACKGROUND: We evaluated the efficacy of high-flow nasal cannula (HFNC) therapy, a promising respiratory support method for acute hypoxemic respiratory failure (AHRF). METHODS: We conducted a retrospective single-center cohort study comparing the periods before (June 2010 to May 2012) and after (June 2012 to May 2014) HFNC introduction (pre- and post-HFNC periods). During these periods, we treated cases of AHRF treated with any respiratory support (mechanical ventilation, nasal CPAP, and HFNC) and compared inhospital mortality, ICU/intermediate care unit/hospital stay, and need for mechanical ventilation. RESULTS: Eighty-nine subjects were treated with HFNC (42 pre-HFNC and 47 post-HFNC) and 82 treated with invasive ventilation) and 89 subjects (53 treated with HFNC, 43 treated with NIV, and 13 treated with invasive ventilation) identified from 782 pre-HFNC and 950 post-HFNC records of acute respiratory failure who required emergent admission to the respiratory care department were analyzed. Overall, the in-hospital mortality rate was similar, although there was a non-significant and slight decrease from 35 to 27% (P = .26). There was no significant difference among ICU, intermediate care unit (P = .8), or hospital (P = .28) stay. In the post-HFNC period, significantly fewer subjects required mechanical ventilation (NIV or invasive ventilation) (100% vs 63%; P < .01). Additionally, there were significantly fewer ventilator days (median interquartile range) of 3 [2–4] vs 2 [0–3] d, P < .01) and more ventilator-free days (median interquartile range) of 18 [0–25] vs 26 [20–27] d, P < .01). CONCLUSIONS: HFNC might be an alternative for AHRF subjects with NIV intolerance. Key words: acute hypoxemic respiratory failure, respiratory support, high-flow nasal cannula, invasive ventilation, noninvasive ventilation, ventilator-free days. [Respir Care 2015;60(10):1390–1396. © 2015 Elsevier Enterprises]

Introduction

Acute respiratory failure (ARF) is a fatal complication of various respiratory diseases. It is the cause of ~30% of ICU admissions and is associated with poor outcomes. Despite early and appropriate treatment, ARF may persist. Optimum oxygen administration is critical to maintain satisfactory oxygenation during this critical period. Noninvasive ventilation (NIV) has increasingly been used to manage ARF of various etiologies. NIV is associated not only with less need for endotracheal intubation, but also with reduced occurrence of complications (eg, nosocomial infections), decreased ICU stay, and lower overall cost of hospitalization in selected subjects. The authors have disclosed no conflicts of interest.

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Effect of Very-High-Flow Nasal Therapy on Airway Pressure and End-Expiratory Lung Impedance in Healthy Volunteers

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BACKGROUND: Previous research has demonstrated a positive linear correlation between flow delivered and airway pressures generated by high-flow nasal therapy. Current practice is to use flows over a range of 30–60 L/min; however, it is technically possible to apply higher flows. In this study, airway pressure measurements and electrical impedance tomography were used to assess the relationship between flows of up to 100 L/min and changes in lung physiology. METHODS: Fifteen healthy volunteers were enrolled into this study. A high-flow nasal system capable of delivering a flow of 100 L/min was purpose-built using a modified system. Airway pressure was measured via the nasopharynx, and cumulative changes in end-expiratory lung impedance were recorded using the PulmoVista 500 system at gas flows of 30–100 L/min in increments of 10 L/min. RESULTS: The mean age of study participants was 43 years (range 22–64) and the mean ± SD height was 177.8 ± 7.0 cm, while mean ± SD weight was 89.7 ± 16 kg, and 47% were male. Flows ranged from 30 to 100 L/min with resultant mean ± SD airway pressures of 2.7 ± 0.7 to 10.5 ± 2.5 cm H2O. A cumulative and linear increase in end-expiratory lung impedance was observed with increasing flows, as well as a decrease in breathing frequency. CONCLUSIONS: Measured airway pressure and lung impedance increased linearly with increased gas flow. Observed airway pressures were in the range used clinically with face-mask noninvasive ventilation. Developments in delivery systems may result in this therapy being an acceptable alternative to face-mask noninvasive ventilation. Key words: oxygen therapy; high-flow nasal therapy; humidification; airway pressure; lung volume [Respir Care. 2015;60(10):1397–1401. © 2015 Lippincott Williams & Wilkins]

Introduction

Traditionally, a tightly sealed mask or an intubated airway has been used to deliver positive pressure to the lungs.

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Research performed in the Cardiopulmonary and Vascular Intensive Care Unit at Auckland City Hospital was supported in part by an unrestricted grant from Fisher & Paykel Healthcare. Fisher & Paykel Healthcare also supplied the equipment used in this study. This trial was registered prospectively at www.anzctr.org.au (ACTRN12350004779154). The authors have declared a relationship with Fisher & Paykel Healthcare.

High-flow nasal therapy provides controlled oxygen concentrations and low levels of positive airway pressure via a nasal interface. It offers clinicians and patients an alternative mechanism for delivering low-level pressure without some of the complications and comfort issues associated with other methods. High-flow nasal therapy has been shown to improve oxygenation in diverse patient groups and is being used increasingly as an alternative to mechanical ventilatory support. These devices have also been shown to be efficacious when used in subjects with...

Dr Parke presented a version of this report at the 26th Annual Congress of the European Society of Intensive Care Medicine, held October 5-8, 2013, in Paris, France.

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Pediatric Applications

- **Mild to moderate hypoxemia**
  - Post-extubation

  R. Martinez, RRT, B. Lifkowitz, MD, Resp Care 2004  Case Report: Successful extubation of a former Premature infant using Vapotherm High Flow Therapy After Multiple Attempts Using Conventional Methods

  - RSV/Bronchiolitis
  - Asthma
  - Cystic fibrosis
  - Atelectasis
  - Pneumonia
  - Nitric Oxide Application
  - Alternative to BiPAP or NIV - When used for:
    - Early stage mild to moderate hypoxemia
    - Heliox applications
Supporting evidence

- High-Flow Oxygen Administration by Nasal Cannula for Adult and Perinatal Patients. Jeffrey J Ward MEd RRT FAARC. RESPIRATORY CARE • JANUARY 2013 VOL 58 NO 1
- What is the evidence for the use of highflow nasal cannula oxygen in adult patients admitted to critical care units? A systematic review. Jodie Kernick RN, Grad Dip ICU, Grad Cert Retrieval Nursing, MNurs (Candidate)a,*, Judy Magarey RN, Crit Care Cert, MNurs, Dmus. Australian Critical Care (2010) 23, 53—70
- Children With Respiratory Distress Treated With High-Flow Nasal Cannula. Thomas Spentzas, MD, MSc, et.al. J Intensive Care Med September 2009 vol. 24 no. 5 323-328
General Vapotherm Guideline

<table>
<thead>
<tr>
<th>Age*</th>
<th>Flowrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 6 months</td>
<td>1 - 8 LPM</td>
</tr>
<tr>
<td>6 months- 2 years</td>
<td>8 - 10 LPM</td>
</tr>
<tr>
<td>2 years - 6 years</td>
<td>10 - 15 LPM</td>
</tr>
<tr>
<td>6 years – 10 years</td>
<td>12 - 20 LPM</td>
</tr>
<tr>
<td>10 years – 15 years</td>
<td>15 - 25 LPM</td>
</tr>
<tr>
<td>15 years – 18 years</td>
<td>20 - 30 LPM</td>
</tr>
<tr>
<td>&gt; 18 years</td>
<td>20 – 40 LPM</td>
</tr>
</tbody>
</table>

* Consider patient weight

1. Initial aim is to decrease FiO2 to below .30 - .40, then the flowrate may be decreased incrementally until a low flowrate with room air (21%) is tolerated. Then a challenge to room air is recommended.
2. Recommended Temperature: setting is between 35 – 40 degrees Centigrade.
3. Indications: Mild to moderate respiratory distress
4. Failure Criteria: Requirements of flowrates on the highest side of the patient’s range with FiO2 > .60 for 4 – 6 hours. Proceed to NCPAP, BiPAP or intubation.

Example of a Physicians order will appear as follows:

Example #1

Vapotherm @ 25 LPM
FiO2 to maintain SpO2 between 90-95%
Or
FiO2 to maintain SpO2 greater than 92%

Example #2

Humidified oxygen @ 25 LPM
FiO2 to maintain SpO2 between 90-95%
Or
FiO2 to maintain SpO2 greater than 92%
Contraindications

• Refractory hypoxemia
  – 50 mmHg PaO$_2$ @ >.50 FiO$_2$ over 6/12 hrs
• Progressive hypercapnea
• Increased WOB
• Unconscious patients and poor respiratory effort
• Patient discomfort despite attempts to ease anxiety
HFNC Impressions

• HFNC can effectively be used to treat patients with moderate levels of hypoxemic respiratory failure.
• HFNC considered as initial appliance in ED for hypoxemia or dyspnea
• HFNC Flow support to meet inspiratory demands
• Distending CPAP similar to CPAP
• HFNC heat and humidity improve comfort and tolerance
• HFNC will likely require some additional education for nursing and medical staff.