Nasal High Flow Humidification with or without Oxygen for COPD Management

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Objectives

• How it works
• COPD
  – Management today
  – The role of NHFC
  – Evidence
• Research/Case Studies
### Types of oxygen delivery devices

<table>
<thead>
<tr>
<th>Device</th>
<th>Flow Rates</th>
<th>Delivered O₂*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nasal cannula</td>
<td>1 L/min</td>
<td>21%-24%</td>
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<tr>
<td></td>
<td>2 L/min</td>
<td>25%-28%</td>
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<td></td>
<td>3 L/min</td>
<td>29%-32%</td>
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<td></td>
<td>4 L/min</td>
<td>33%-36%</td>
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<td></td>
<td>5 L/min</td>
<td>37%-40%</td>
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<td></td>
<td>6 L/min</td>
<td>41%-44%</td>
</tr>
<tr>
<td>Simple oxygen face mask</td>
<td>6-10 L/min</td>
<td>35%-60%</td>
</tr>
<tr>
<td>Face mask with O₂ reservoir (nonrebreathing mask)</td>
<td>6 L/min</td>
<td>60%</td>
</tr>
<tr>
<td></td>
<td>7 L/min</td>
<td>70%</td>
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<td></td>
<td>8 L/min</td>
<td>80%</td>
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<td></td>
<td>9 L/min</td>
<td>90%</td>
</tr>
<tr>
<td></td>
<td>10-15 L/min</td>
<td>95%-100%</td>
</tr>
<tr>
<td>Venturi mask</td>
<td>4-8 L/min</td>
<td>24%-40%</td>
</tr>
<tr>
<td></td>
<td>10-12 L/min</td>
<td>40%-50%</td>
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</tbody>
</table>

*Percentage is approximate.*
Modern Oxygen Delivery & its Limitations

- Drying of the airway
- Energy expenditure
- Patient discomfort and noncompliance
- Thicken secretions
- Failure to meet inspiratory demand
- Inaccurate oxygen delivery
- Multiple interfaces required

Leigh 1974; Waugh & Granger 2004
What is Nasal High Flow?

- Gas source
- Humidification
- Heated circuit
- Nasal Cannula
What is Nasal High Flow?

• Form of respiratory support
• Delivers higher flow rates than traditional oxygen delivery devices
• Delivers heat and humidification
• Improves gas exchange and reduces work of breathing

HFNC Benefits

1. Respiratory Support
   • Reduction of dead space
   • PEEP effect
2. Humidification
3. Supplemental Oxygen
4. Patient comfort
1. Respiratory Support - Dead Space Reduction

Approximately 150 ml of inhaled breath is from dead space - one third of inspiration
1. Respiratory Support - Dead Space Reduction

- Clearance of expired air in the upper airways\(^1\)
- Reduces rebreathing of gas high in CO\(_2\) and depleted O\(_2\)\(^{1,2}\)
- Increases alveolar ventilation\(^1\)

1. Respiratory Support - Dead Space Reduction

1. Vapotherm.com
1. Respiratory Support – Airway Pressure

- Compared to unassisted breathing, tidal volume increases and respiratory rate reduces as flow increases.

![Tidal volume (Vt) comparison graph](image)

Mundel et al. J Appl Physiol. 2013
1. Respiratory Support – Airway Pressure

- The slower breath and longer expiratory phase allows for improved alveolar ventilation
  - Breath- and flow-dependent airway pressure
  - Promotes slow and deep breathing
  - Increases alveolar ventilation
2. Humidification

- Unwarmed dry gas is associated with nasal & oral dryness, eye irritation, nasal & eye trauma, gastric distention, and aspiration
- Induced bronchoconstriction
- Mucociliary clearance

References:
2. Roca et al. Respir Care. 2010
2. Humidification

Water Droplet

Molecular Humidification

1. Parke, et al. J Respir Care, 2011
3. Supplemental Oxygen

- Ability to meet the patients inspiratory flow rate results in accurate knowledge of delivered FiO2.

1 Ritchie J. et al. Anaesth Intensive Care, 2011
4. Patient Comfort

• Heating and humidification improves patient comfort and tolerance of therapy
• Comfortable and easy to use
• Low level of patient compliance needed

1. Roca, O et al. Respir Care 2010
2. Maggore et al AJCCM 2014
Benefits of HFNC

1. Warmed and humidified gas keeps mucus more fluid, aid in mouth dryness, and greater overall comfort
2. Improves air/O₂ delivery with C₀₂ washout of upper airway
3. PEEP effect reduces the work of breathing
Patients that Benefit from HFNC

- Today in the hospital environment, HFNC is being utilized for a variety of patients with different diseases
  - Intensive Care
  - COPD
  - Tracheostomy
  - Post CABG
  - CHF
  - Extubation
COPD is an umbrella term used to describe progressive lung diseases including emphysema, chronic bronchitis, non-reversible asthma, and some forms of bronchiectasis.

Smoke and pollutants enter the lung, damaging or destroying the cilia. Airways become swollen, narrow, and lose their elasticity.

Sufferers experience increased breathlessness, frequent coughing, wheezing, and chest tightness.
COPD in the United States

Rule of 15

- 15 million Americans have been diagnosed
- 15 million Americans are undiagnosed
- 15 million physician office visits
- 1.5 million ER Visits
- 150 million days of disability

Direct Costs of COPD

- ER visits
- Length of stay
- Avoidable admissions

Cost were significantly higher for readmissions to that of initial stays. On average a COPD 30-day readmission costs more than 50% higher than any other diagnosis.
Direct Costs of COPD

Costs attributable to having COPD were $32.1 billion in 2010 with a projected increase to $49.0 billion by 2020.

Medicare paid 51% of those costs with 25% paid by Medicaid and 18% by private insurance in 2010.
Causes of COPD Exacerbation

1/3 of COPD exacerbations = viral respiratory infections

Chest tightness

Increased dyspnea

Productive Cough

Fatigue

Confusion

Hospital
COPD Exacerbations

Hospital Mortality rate for COPD Exacerbation = 10%
25% require an ICU Stay
Breaking the Cycle

Keep mucus thin
- Improves mucus clearance
- Reduce bacterial/viral infections

Improve Ventilation
- Hypoxemia improves
- Less Anxious

Maintain QOL
- Stay active
- Reduce rate of declining lung function
**History**

**Increasing Research...**

*Graph showing increasing research interest in nasal high flow from 1970 to 2016.*

**Topic: nasal high flow**

- **Publications**
- **Publications (current year estimated)**
- **Relative Research Interest**
- **Relative Research Interest (smoothed)**

*Graph sourced from Kingston Healthcare Company.*
Present COPD Management

- Smoking Cessation
- Immunizations
- Medications
- Pulmonary Rehab
- Pharmacotherapy
Rea et al. 2010, compared long-term humidification therapy with usual care on frequency of exacerbations, lung function, quality of life and exercise capacity in COPD patients.

Methodology
- COPD or bronchiectasis patients
- n=48 usual treatment
- n=60 LTHT group (>2 hrs every day for 12 months)
- Settings were 37° C at a flow rate of 20 or 25 mL/min

- Median time to first exacerbation was significantly longer from 27 to 52 days
- Significantly lower number of exacerbation days over 12 months from 33.5 to 18.2 days
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**Other Benefits**
- Decreased exacerbation frequency by 18%
- Decreased no. of exacerbation days by 46%
- Increased median time to first exacerbation by 95%
- Decreased antibiotic use by 40%
- Increased Forced Expiratory Volume (FEV1) by 10%
- Increased Forced Vital Capacity (FVC) by 15%
- Improved Quality of Life Scores (Total)
NHFC for COPD in the Home

Additional studies are underway to establish the role of NHF in the home and preliminary data is promising.

Data suggests that benefits include a reduction of symptoms and risks.

Reduced Symptoms
- Relieves Symptoms
  - SGRQ was significantly lower than usual care (Rea et al 2010)
- Improves Exercise Tolerance
  - Improved exercise performance (Chatila et al 2004)
- Improves Health Status
  - SGRQ was significantly lower than usual care (Rea et al 2010)

Reduced Risks
- Prevent Disease Progression
  - Improved mucociliary clearance may slow the rate to disease progression (Hasani et al 2008)
- Prevent and Treat Exacerbations
  - Lower number of exacerbation days/long time to first exacerbation/trend to reduced number of exacerbations (Rea et al 2010)
- Reduce Mortality
Parke, et al. 2009, prospective study to determine whether a level of positive airway pressure was generated in participants receiving NFH.

**Methodology**
- Nasopharyngeal airway pressure measured in postop cardiac surgery adults.
- n= NHF 35lpm
- n= Standard Facemask at 35lpm
- Measurements with mouth open and closed
- Nasopharyngeal catheter placed to record measurements
Parke, et al. 2013, This study describes the airway pressures generated at 3 flows in subjects receiving NHF and reports for the first time the pressure delivered during different phases of the respiratory cycle by NHF

**Methodology**
- Elective cardiac surgery patients
- Gas flows of 30, 40, & 50
- Measurements performed in random order
- Measurements with mouth closed
- Nasopharyngeal catheter placed to record measurements

Fig. 3. Pressure profiles from one subject at increasing gas flows with the Optiflow nasal high flow oxygen system.
Stephan et al. 2015, 6 centre randomized trial comparing high flow nasal oxygen with BiPAP. The primary outcome was treatment failure.

**Methodology**
- 830 post-op cardiothoracic surgery patients
- n=416 BiPAP
- n=414 High Flow Nasal Oxygen
- Settings were 50% FiO2. 50lpm HF, 8/4 BiPAP
Nishimura, 2016 Review article regarding principles and benefits of High Flow and their physiological effects.

Assessments
- Adverse effects of lack of humidification
- Hypercapnic Respiratory Failure
- Physiological Effect
- Interface
- Conditions
Fraser et al. 2016 A randomized crossover study was performed to assess the short-term physiological effects of NHF oxygen in patients with chronic stable COPD.

**Methodology**

- Stable oxygen-dependent COPD patients
- Baseline recordings taken on LTOT
- Each therapy was given for 20 minutes
- Settings were 2-4lpm NC and 30lpm NHF
Cuquemelle, et al. 2012, studied respiratory comfort in patients with acute hypoxemic respiratory failure receiving standard oxygen therapy with no humidification or heated and humidified high flow oxygen (HHFO2).

**Methodology**
- Dryness was auto-evaluated and blindly assessed by an otorhinolaryngologist.
- Assessments at baseline, H4, and H24.
- Crossover done, assessed at H28.
- Temperature of 37° degrees

**Assessments**
- Pharyngeal dead space washout
- PEEP effect
- Increase in end-inspiratory lung volume
- Humidification and tolerance
Chatila, et al. 2004 This study compared the effects of high flows of humidified oxygen to conventional low-flow oxygen delivery at rest and during exercise in patients with COPD.

Methodology
- Outpatient exercise laboratory
- COPD, stable no exacerbation
- Age 54 ± 6, FEV1 23 ±6%
- Cycle ergometer for up to 12 minutes
- HFO 20lpm
- Comparable FIo2
Ramona:

Original CXR

7 days on HFNC
High Flow O2 Therapy

- Reduced Respiratory Rate
- Improved oxygenation
- PEEP effect
- Increased tidal volume
- Improved dyspnea
- Reduced mortality
- More comfortable
Summary

• Existing O2 delivery methods today are limited
• Non-pharma therapies for managing COPD in the home are few
• Increasing evidence that during an acute respiratory event, e.g. COPD exacerbation, HFNC has a role to play and is equal to bi-level in terms of outcome, yet preferred by the user
• Studies are underway to establish the role of HFNC for long-term use in the home, e.g. COPD; preliminarily data promising
Questions