Nasal High-Flow

Salvatore M. Maggiore, MD, PhD
Rome, Italy

smmaggiore@rm.unicatt.it
Conflict of interest

• Principal Investigator: RINO trial
  o Nasal high-flow vs Venturi mask after extubation
  o NCT02107183
  o Sponsored by Fisher & Paykel
• Received research grants from Fisher & Paykel and lecture fees from Draeger
Nasal High-Flow Oxygen Therapy

- High flows of inspired gas up to 60 L/min
- Full humidification (37 °C, 100 RH, 44 mg H₂O/L)
NHF: potential advantages

- Matching pt’s inspiratory flow (stable FiO2)
- CPAP effect (lung recruitment)
- Washout of nasopharyngeal deadspace
- Better humidification & comfort
Low CPAP effect, increasing linearly with flow

### Nasopharyngeal pressure (cmH₂O) [Flow 35 L/min]

<table>
<thead>
<tr>
<th></th>
<th>NHF Mouth Closed</th>
<th>NHF Mouth Open</th>
<th>FM Mouth Closed</th>
<th>FM Mouth Open</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>M</strong></td>
<td>2.7</td>
<td>1.2</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td>± SD</td>
<td>± 1.0</td>
<td>± 0.8</td>
<td>± 0.6</td>
<td>± 0.4</td>
</tr>
</tbody>
</table>


*Parke R, et al. Respir Care 2011;56:1151-5*
NHF: physiologic effects & mechanisms of action

Mundel T et al. JAP 2013;114:1058-65
NHF: physiologic effects & mechanisms of action

- Slower and deeper breathing (RR 16→9 b/m; V₉ 0.85→1.30 L)
- ↑ Expiratory time (3.1→6.0 s)
- ↓ Deadspace (V₉/V₉ 0.2→0.1 L/m)

*Mundel T et al. JAP 2013;114:1058-65*
Washout of nasopharyngeal dead space

The high gas flow decreases the upper airway dead space like trans-tracheal airway insufflation.
Nasal High-Flow oxygen therapy

Clinical data
NHF vs low flow O2: improved gas exchange and comfort

20 hypoxemic pts (SpO2<96% with FiO2 50%)
Venturi Mask vs NHF for 30 min

Roca O, et al. Respir Care 2010;55:408-413
Oxygen delivery through high-flow nasal cannulae increase end-expiratory lung volume and reduce respiratory rate in post-cardiac surgical patients

20 pts after cardiac surgery

Low flow O₂ (cannulae or face mask) vs NHF with increasing O₂ flow

Table 2 Outcome variables. Low-flow oxygen compared with HFNCs

<table>
<thead>
<tr>
<th>Variable</th>
<th>Low-flow oxygen [mean (sd)]</th>
<th>HFNC [mean (sd)]</th>
<th>Mean difference [mean (sd)]</th>
<th>95% confidence interval</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>End-expiratory lung impedance</td>
<td>419 (212.5)</td>
<td>1936 (212.9)</td>
<td>1517 (46.6)</td>
<td>1425, 1608</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Mean airway pressure (cm H₂O)</td>
<td>-0.3 (0.9)</td>
<td>2.7 (1.2)</td>
<td>3.0 (1.3)</td>
<td>2.4, 3.7</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Respiratory rate (bpm)</td>
<td>20.9 (4.4)</td>
<td>17.5 (4.6)</td>
<td>-3.4 (2.8)</td>
<td>-2.0, -4.7</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Borg score</td>
<td>2.7 (2.6)</td>
<td>1.9 (2.3)</td>
<td>-0.8 (1.2)</td>
<td>-0.1, -1.4</td>
<td>0.023</td>
</tr>
<tr>
<td>Tidal variation (units)</td>
<td>1512 (195.0)</td>
<td>1671 (195.1)</td>
<td>159 (21.6)</td>
<td>117, 201</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>(P_{a_o_2}/F_{l_o_2}) ratio (mm Hg)</td>
<td>160 (53.7)</td>
<td>190.6 (57.9)</td>
<td>30.6 (25.9)</td>
<td>17.9, 43.3</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
NHF in the ED

Humidified High Flow Nasal Oxygen During Respiratory Failure in the Emergency Department: Feasibility and Efficacy

Hugo Lenglet MD, Benjamin Sztrymf MD, Christophe Leroy MD, Patrick Brun MD, Didier Dreyfuss MD, and Jean-Damien Ricard MD PhD

17 pts with hypoxemic ARF & dyspnea

<table>
<thead>
<tr>
<th></th>
<th>Before NHF</th>
<th>After 1h NHF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Borg scale</td>
<td>6</td>
<td>3 *</td>
</tr>
<tr>
<td>VAS dyspnea</td>
<td>7</td>
<td>3 *</td>
</tr>
<tr>
<td>RR, b/min</td>
<td>28</td>
<td>25 *</td>
</tr>
<tr>
<td>SpO2, %</td>
<td>90</td>
<td>97 *</td>
</tr>
</tbody>
</table>

NHF is feasible in the ED, and it alleviated dyspnea and improved respiratory parameters in subjects with hypoxemic ARF

Lenglet H et al. Respir Care 2012;57:1873–1878
**NHF in hypoxemic ARF**

38 pts with ARF receiving NHF for 48h; 9 pts (24%) were intubated

**Beneficial effects of humidified high flow nasal oxygen in critical care patients: a prospective pilot study**

Intubated pts (≈ at 1h):
- ↑ RR (30 vs 24 b/m)
- ↓ SpO2 (96 vs 98%)
- ↓ P/F ratio (91 vs 201)
- ↑ T/A asynchrony (75 vs 10% pts)

*Sztrymf et al. Intensive Care Med 2011;37:1780–1786*
NHF vs mask HF: improved success rate & compliance

A Preliminary Randomized Controlled Trial to Assess Effectiveness of Nasal High-Flow Oxygen in Intensive Care Patients

Rachael L Parke MHSc, Shay P McGuinness, et al.

60 pts with mild to moderate hypoxemic ARF
High-flow face mask vs NHF for 24 h

Randomization 60

Nasal High Flow 30
- Missing Data Refused consent: 1
  - Success 26
  - Failure 3
    - NIV 3

Face Mask Oxygen Therapy 30
- Missing Data Refused consent: 1
  - Screen failure: 2
  - Success 15
    - Failure 12
      - NIV 7
      - Nasal High Flow 5
      - NIV 1

Fewer desaturations with NHF (15 vs 26)

Parke R, et al. Respir Care 2011;56:265-70
NHF vs face mask after extubation

High-Flow Nasal Cannula Versus Conventional Oxygen Therapy After Endotracheal Extubation: A Randomized Crossover Physiologic Study

Nuttapol Rittayamai MD, Jamsak Tscheikuna MD, and Pitchayapa Ruijwit MD

17 pts after extubation
NHF vs non-rebreathing face mask for 30’

Rittayamai N, et al. Respir Care 2014;59:485–490
Nasal High-Flow oxygen therapy after extubation

Inclusion Criteria: mechanical ventilation > 24h, P/F ≤ 300 at the beginning of SBT, successful SBT (1 hour: PSV 6-8 cmH2O - PEEP 0, or T-piece)

Exclusion Criteria: tracheostomy, anticipated need for NIV post-extubation (prophylactic), age < 18, pregnancy

Randomization: NHF vs Venturi mask oxygen therapy after extubation

Settings: FiO2 set to obtain SpO2 92-98% (88-95% in COPD), gas flow 50 L/min (with NHF)

Measurements (at 1, 3, 6, 12, 24, 36, and 48 hours):
arterial blood gases, respiratory rate, discomfort related to the interface and to dryness symptoms (patients’s rating on a numerical scale from 0 – min – to 10 – max), incidence of desaturations and interface’s displacement, need for reintubation or NIV

Maggiore SM et al. AJRCCM 2014;190:282-288
Nasal High-Flow oxygen therapy after extubation

No. 197 Assessed for Eligibility

No. 92 Excluded
  No. 68 Not Meeting Inclusion Criteria*
  No. 24 Refused to Participate

No. 105 Randomized

No. 53 Assigned to Receive NHF
  No. 53 Received NHF as Assigned

No. 53 Included in Analysis

No. 4 Post-Extubation Respiratory Failure
  No. 2 NIV
  No. 2 Success

No. 52 Assigned to Receive Venturi mask
  No. 52 Received Venturi mask as Assigned

No. 52 Included in Analysis

No. 18 Post-Extubation Respiratory Failure
  No. 8 NIV
  No. 7 Success

Maggiore SM et al. AJRCCM 2014;190:282-288
Nasal High-Flow oxygen therapy after extubation

<table>
<thead>
<tr>
<th>Control Group (n = 52)</th>
<th>NHF (n = 53)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, yr</td>
<td>64 ± 17</td>
<td>65 ± 18</td>
</tr>
<tr>
<td>Male sex, n (%)</td>
<td>35 (67.3)</td>
<td>33 (62.3)</td>
</tr>
<tr>
<td>SAPS II</td>
<td>44 ± 16</td>
<td>43 ± 14</td>
</tr>
<tr>
<td>Type of admission</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medical, n (%)</td>
<td>31 (60)</td>
<td>35 (66)</td>
</tr>
<tr>
<td>Surgical-trauma, n (%)</td>
<td>21 (40)</td>
<td>18 (34)</td>
</tr>
<tr>
<td>Cause of acute respiratory failure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pneumonia, n (%)</td>
<td>24 (46.2)</td>
<td>24 (45.3)</td>
</tr>
<tr>
<td>Multiple trauma, n (%)</td>
<td>12 (23.1)</td>
<td>11 (20.8)</td>
</tr>
<tr>
<td>Atelectasis, n (%)</td>
<td>5 (9.6)</td>
<td>4 (7.5)</td>
</tr>
<tr>
<td>Shock, n (%)</td>
<td>3 (5.8)</td>
<td>5 (9.4)</td>
</tr>
<tr>
<td>Cardiogenic pulmonary edema, n (%)</td>
<td>3 (5.8)</td>
<td>3 (5.7)</td>
</tr>
<tr>
<td>Cardiac arrest, n (%)</td>
<td>2 (3.8)</td>
<td>3 (5.7)</td>
</tr>
<tr>
<td>Other, n (%)*</td>
<td>3 (5.8)</td>
<td>3 (5.7)</td>
</tr>
<tr>
<td>Length of mechanical ventilation before inclusion, d</td>
<td>5.2 ± 3.7</td>
<td>4.6 ± 4.1</td>
</tr>
<tr>
<td>Length of ICU stay before inclusion</td>
<td>5.6 ± 4.4</td>
<td>5.2 ± 4.4</td>
</tr>
<tr>
<td>PaO₂, mm Hg</td>
<td>93.4 ± 24.2</td>
<td>89.9 ± 19.5</td>
</tr>
<tr>
<td>PaCO₂, mm Hg</td>
<td>36 ± 7.1</td>
<td>34.7 ± 7.6</td>
</tr>
<tr>
<td>Scao₂, %</td>
<td>97.2 ± 2.6</td>
<td>96.9 ± 2.0</td>
</tr>
<tr>
<td>FiO₂, %</td>
<td>39 ± 7</td>
<td>38 ± 7</td>
</tr>
<tr>
<td>PaO₂/FiO₂, mm Hg</td>
<td>241.7 ± 51.1</td>
<td>239.4 ± 42.4</td>
</tr>
<tr>
<td>Respiratory rate, breaths/min</td>
<td>23 ± 6</td>
<td>23 ± 5</td>
</tr>
<tr>
<td>Heart rate, beats/min</td>
<td>91 ± 15</td>
<td>92 ± 19</td>
</tr>
<tr>
<td>Mean arterial pressure, mm Hg</td>
<td>94 ± 15</td>
<td>94 ± 12</td>
</tr>
</tbody>
</table>
Nasal High-Flow oxygen therapy after extubation

Maggiore SM et al. AJRCCM 2014;190:282-288
Nasal High-Flow oxygen therapy after extubation

Maggiore SM et al. AJRCCM 2014;190:282-288
Nasal High-Flow oxygen therapy after extubation

With NHF:
- Fewer pts with interface displacements (32% vs 56%, p=0.01)
- Fewer pts with oxygen desaturations (40% vs 75%, p<0.01)

<table>
<thead>
<tr>
<th>Cause of Endotracheal Intubation</th>
<th>Control Group (n = 52)</th>
<th>NHF (n = 53)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noninvasive Ventilation, n (%)</td>
<td>8 (15.4)</td>
<td>2 (3.8)</td>
<td>0.042</td>
</tr>
<tr>
<td>Endotracheal Intubation, n (%)</td>
<td>11 (21.2)</td>
<td>2 (3.8)</td>
<td>0.005</td>
</tr>
<tr>
<td>Cause of Endotracheal Intubation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypercapnia with respiratory acidosis, n (%)</td>
<td>0</td>
<td>0</td>
<td>N/A</td>
</tr>
<tr>
<td>Changes in mental status, n (%)</td>
<td>1 (1.9)</td>
<td>1 (1.9)</td>
<td>0.989</td>
</tr>
<tr>
<td>Oxygen desaturation or hypoxia, n (%)</td>
<td>6 (11.5)</td>
<td>1 (1.9)</td>
<td>0.047</td>
</tr>
<tr>
<td>Unbearable dyspnea with respiratory muscle failure, n (%)</td>
<td>4 (7.7)</td>
<td>1 (1.9)</td>
<td>0.162</td>
</tr>
<tr>
<td>Persistent hypotension, n (%)</td>
<td>2 (3.8)</td>
<td>0</td>
<td>0.149</td>
</tr>
<tr>
<td>Inability to clear secretions, n (%)</td>
<td>6 (11.5)</td>
<td>1 (1.9)</td>
<td>0.047</td>
</tr>
</tbody>
</table>
The RINO Trial
(ReINtubation rate after Oxygen therapy)

• Multicenter, randomized, controlled, phase III, open trial (NCT02107183)
• 500 patients
• Nasal high-flow vs Venturi mask after extubation
• Study hypothesis: using Optiflow for delivering oxygen therapy after extubation may reduce the extubation failure rate and the need for reintubation as compared with the Venturi mask
Conclusions

• Available data suggest that NHF is an effective method for delivering oxygen therapy:
  – better than conventional, low-flow devices in terms of gas exchange, respiratory rate, and comfort
  – safer than face mask, with less interface displacement and less oxygen desaturations

• NHF may play a role in protecting extubation and might improve clinical outcomes in patients with hypoxemic respiratory failure