Non-invasive Positive Pressure Ventilation
The Who, the When, and the How

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Disclosure

• I have no financial conflicts of interests to disclose
• I have given a variation of this talk before...but I try to keep it updated...
Outline

• Terminology
• Case studies
• Indications
• Contraindications
• Clinical Applications
Terminology

• Noninvasive ventilation
  • Means of providing respiratory assistance without the use of endotracheal intubation
  • Typically provides assistance with gas exchange, but also relieves severe dyspnea
  • Beyond providing oxygen supplementation
Terminology

• CPAP – Continuous positive airway pressure
• BPAP – Bilevel positive airway pressure
  • BiPAP® - Respironics
  • VPAP® - ResMed
  • Bilevel – mechanical ventilation mode
Terminology

- **IPAP**
- **EPAP**
- **BiFlex**
- **CPAP**
- **BPAP**

Respiratory Cycle:
- Inspiration
- Exhalation

Pressure support
**Terminology**

- **A-PAP** – Autotitrating PAP
- **BPAP S** – Bilevel PAP, spontaneous
- **BPAP S/T**
- **Adapt Servo Ventilator (ASV)**
- **Auto SV**
- **VPAP** – Variable PAP
- **AVAPS** – Average Volume Assured Pressure support
- **OptiFlow**
- **Respironics V60 ventilator**
- **Trilogy**
Terminology: Interface

- Nasal mask
- Nasal pillows
- Full face mask
- Face shield
- Oral mask
- Chin strap
Case 1

- 72 year old with history of CHF (LVEF 30%), ischemic cardiomyopathy, HTN, and CKD presents with four day history of progressive dyspnea at rest. She denies any fevers, chills, or rigors. She has been sleeping in a recliner for the last two nights.

- BP 110/79, HR 100, RR 30, Temp 37.6°C, O₂ sat 90%

- She appears to be in slight respiratory distress and she does not wish to lie down to be examined. Her JVP is 12. You hear an S₃ and crackles bilaterally. She has 2+ pitting edema bilaterally.
Case 1

In addition to diuretics, what is the next best means of respiratory support for this patient?

A. Oxygen by nasal cannula
B. High flow humidified oxygen therapy
C. Continuous positive airway pressure pressure therapy
D. Adaptive servo ventilation
E. Endotracheal intubation
Physiology
CPAP

• In acute CHF
  • Increased intrathoracic pressure results in decreased preload
  • Improves afterload
CPAP vs BPAP in cardiogenic pulmonary edema

Gray, NEJM 2008;359:142
Clinical Applications

CHF

<table>
<thead>
<tr>
<th>Variable</th>
<th>Standard Oxygen Treatment (N = 367)</th>
<th>CPAP or NIPPV (N = 702)</th>
<th>Odds Ratio (95% CI)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dyspnea score§</td>
<td>3.9</td>
<td>4.6</td>
<td>0.7 (0.2 to 1.3)</td>
<td>0.008</td>
</tr>
<tr>
<td>Pulse rate (beats/min)</td>
<td>13</td>
<td>16</td>
<td>4 (1 to 6)</td>
<td>0.004</td>
</tr>
<tr>
<td>Blood pressure (mm Hg)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Systolic</td>
<td>34</td>
<td>38</td>
<td>3 (1 to 8)</td>
<td>0.17</td>
</tr>
<tr>
<td>Diastolic</td>
<td>22</td>
<td>22</td>
<td>0 (1 to 3)</td>
<td>0.95</td>
</tr>
<tr>
<td>Respiratory rate (breaths/min)</td>
<td>7.1</td>
<td>7.2</td>
<td>0.2 (-0.8 to 1.1)</td>
<td>0.74</td>
</tr>
<tr>
<td>Peripheral oxygen saturation (%)</td>
<td>3.5</td>
<td>3.0</td>
<td>-0.4 (-1.4 to 0.6)</td>
<td>0.41</td>
</tr>
<tr>
<td>Arterial pH</td>
<td>0.08</td>
<td>0.11</td>
<td>0.03 (0.02 to 0.04)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Arterial PaO₂ (kPa)</td>
<td>0.7</td>
<td>-0.6</td>
<td>-1.2 (-2.6 to 0.1)</td>
<td>0.07</td>
</tr>
<tr>
<td>Arterial PaCO₂ (kPa)</td>
<td>0.8</td>
<td>1.5</td>
<td>0.7 (0.4 to 0.9)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Serum bicarbonate level (mmol/liter)</td>
<td>1.7</td>
<td>1.8</td>
<td>0.1 (-0.7 to 1.0)</td>
<td>0.77</td>
</tr>
</tbody>
</table>

Gray, *NEJM* 2008;359:142
Clinical Applications

CHF

![Graph showing survival probability over days for noninvasive ventilation (CPAP or NIPPV) versus standard oxygen therapy. The P-value is 0.64.]

No. at Risk

<table>
<thead>
<tr>
<th></th>
<th>CPAP or NIPPV</th>
<th>Standard therapy</th>
</tr>
</thead>
<tbody>
<tr>
<td>667</td>
<td>609</td>
<td>348</td>
</tr>
<tr>
<td>591</td>
<td>583</td>
<td>318</td>
</tr>
<tr>
<td>577</td>
<td>570</td>
<td>307</td>
</tr>
<tr>
<td>567</td>
<td>570</td>
<td>301</td>
</tr>
<tr>
<td>296</td>
<td>292</td>
<td>291</td>
</tr>
</tbody>
</table>

Gray, NEJM 2008;359:142
Clinical Applications
CHF - Mortality

<table>
<thead>
<tr>
<th>Study or subgroup</th>
<th>NPPV n/N</th>
<th>SMC n/N</th>
<th>Risk Ratio M-H,Random,95% CI</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nava 2003</td>
<td>6/65</td>
<td>9/65</td>
<td>0.67 [0.25, 1.77]</td>
<td>10.5 %</td>
</tr>
<tr>
<td>Park 2001</td>
<td>1/16</td>
<td>0/10</td>
<td>1.94 [0.09, 43.50]</td>
<td>1.0 %</td>
</tr>
<tr>
<td>Park 2004</td>
<td>3/56</td>
<td>6/27</td>
<td>0.24 [0.07, 0.89]</td>
<td>5.8 %</td>
</tr>
<tr>
<td>Rsnen 1985</td>
<td>3/20</td>
<td>6/20</td>
<td>0.50 [0.14, 1.73]</td>
<td>6.5 %</td>
</tr>
<tr>
<td>Sharon 2000</td>
<td>2/20</td>
<td>0/20</td>
<td>5.00 [0.26, 98.00]</td>
<td>1.1 %</td>
</tr>
<tr>
<td>Takeda 1997</td>
<td>1/15</td>
<td>3/15</td>
<td>0.33 [0.04, 2.85]</td>
<td>2.2 %</td>
</tr>
<tr>
<td>Takeda 1998</td>
<td>1/11</td>
<td>7/11</td>
<td>0.14 [0.02, 0.98]</td>
<td>2.7 %</td>
</tr>
<tr>
<td>Thys 2002</td>
<td>0/3</td>
<td>1/5</td>
<td>0.50 [0.03, 9.46]</td>
<td>1.2 %</td>
</tr>
</tbody>
</table>

Total (95% CI) 489 441
Total events: 53 (NPPV), 85 (SMC)
Heterogeneity: Tau² = 0.0; Chi² = 12.74, df = 16 (P = 0.69); I² = 0.0%
Test for overall effect: Z = 3.01 (P = 0.0026)

Cochrane Database of Systematic Reviews 2008
Clinical Applications
CHF – Endotracheal Intubations

<table>
<thead>
<tr>
<th>Study or subgroup</th>
<th>NPPV n/N</th>
<th>SMC n/N</th>
<th>Risk Ratio</th>
<th>Risk Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lin 1995</td>
<td>8/50</td>
<td>18/50</td>
<td></td>
<td>0.44 [0.21, 0.93]</td>
</tr>
<tr>
<td>Masip 2000</td>
<td>1/20</td>
<td>6/20</td>
<td></td>
<td>0.17 [0.02, 1.26]</td>
</tr>
<tr>
<td>Nava 2003</td>
<td>13/65</td>
<td>16/65</td>
<td></td>
<td>0.81 [0.43, 1.55]</td>
</tr>
<tr>
<td>Park 2001</td>
<td>3/16</td>
<td>4/10</td>
<td></td>
<td>0.47 [0.13, 1.67]</td>
</tr>
<tr>
<td>Park 2004</td>
<td>4/56</td>
<td>11/27</td>
<td></td>
<td>0.18 [0.06, 0.50]</td>
</tr>
<tr>
<td>Rsnen 1985</td>
<td>6/20</td>
<td>12/20</td>
<td></td>
<td>0.50 [0.23, 1.07]</td>
</tr>
<tr>
<td>Sharon 2000</td>
<td>16/20</td>
<td>4/20</td>
<td></td>
<td>4.00 [1.62, 9.87]</td>
</tr>
<tr>
<td>Takeda 1997</td>
<td>1/15</td>
<td>6/15</td>
<td></td>
<td>0.17 [0.02, 1.22]</td>
</tr>
<tr>
<td>Takeda 1998</td>
<td>2/11</td>
<td>8/11</td>
<td></td>
<td>0.25 [0.07, 0.92]</td>
</tr>
<tr>
<td>Thys 2002</td>
<td>0/3</td>
<td>0/5</td>
<td></td>
<td>0.0 [0.00, 0.00]</td>
</tr>
<tr>
<td><strong>Total (95% CI)</strong></td>
<td><strong>489</strong></td>
<td><strong>441</strong></td>
<td><strong>0.53 [0.34, 0.83]</strong></td>
<td></td>
</tr>
</tbody>
</table>

Total events: 76 (NPPV), 126 (SMC)
Heterogeneity: Tau² = 0.41; Chi² = 34.06, df = 14 (P = 0.002); I² = 59%
Test for overall effect: Z = 2.76 (P = 0.0059)

*Cochrane Database of Systematic Reviews 2008*
Clinical Applications
CHF – Incidence of AMI

<table>
<thead>
<tr>
<th>Study or subgroup</th>
<th>NPPV n/N</th>
<th>SMC n/N</th>
<th>Risk Ratio M-H, Random, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crane 2004</td>
<td>12/40</td>
<td>6/20</td>
<td>1.00 [0.44, 2.27]</td>
</tr>
<tr>
<td>Kelly 2002</td>
<td>9/27</td>
<td>8/31</td>
<td>1.29 [0.58, 2.88]</td>
</tr>
<tr>
<td>Levitt 2001</td>
<td>4/21</td>
<td>5/21</td>
<td>0.80 [0.25, 2.57]</td>
</tr>
<tr>
<td>Masip 2000</td>
<td>5/20</td>
<td>6/20</td>
<td>0.83 [0.30, 2.29]</td>
</tr>
<tr>
<td>Nava 2003</td>
<td>7/65</td>
<td>5/65</td>
<td>1.40 [0.47, 4.18]</td>
</tr>
<tr>
<td>Park 2004</td>
<td>0/56</td>
<td>0/27</td>
<td>0.00 [0.00, 0.00]</td>
</tr>
<tr>
<td>Sharon 2000</td>
<td>11/20</td>
<td>2/20</td>
<td>5.50 [1.39, 21.71]</td>
</tr>
<tr>
<td>Thys 2002</td>
<td>0/3</td>
<td>0/5</td>
<td>0.00 [0.00, 0.00]</td>
</tr>
<tr>
<td><strong>Total (95% CI)</strong></td>
<td><strong>252</strong></td>
<td><strong>209</strong></td>
<td><strong>1.24 [0.79, 1.95]</strong></td>
</tr>
</tbody>
</table>

Total events: 48 (NPPV), 32 (SMC)
Heterogeneity: Tau² = 0.06; Chi² = 6.14, df = 5 (P = 0.29); I² = 19%
Test for overall effect: Z = 0.93 (P = 0.35)

Cochrane Database of Systematic Reviews 2008
Case 2

- 67 year old with severe COPD (FEV$_1$ 30%), CAD, HTN presents with three day history of progressive dyspnea. He has had fevers and increased productive cough.

- On exam, he appears to be in moderate respiratory distress with RR of 35, starting to use accessory muscles, and only able speak few words at a time. His oxygen saturation is 89% on 2 L/min. His lung exam reveals diffuse expiratory wheeze with prolonged expiratory phase.
Case 2

In addition to antibiotics, bronchodilators, and steroids, what additional therapy should you provide?

A. Increase oxygen with the use of a non-rebreather mask
B. Optiflow
C. CPAP
D. BPAP
E. Intubation and mechanical ventilation
Clinical Applications
COPD Exacerbations: Mortality

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>NPPV Events</th>
<th>Total</th>
<th>UMC Events</th>
<th>Total</th>
<th>Weight</th>
<th>Risk Ratio M-H, Fixed, 95% CI</th>
<th>Risk Ratio M-H, Fixed, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avdeev 1998</td>
<td>3</td>
<td>29</td>
<td>9</td>
<td>29</td>
<td>13.8%</td>
<td>0.33 [0.10, 1.11]</td>
<td></td>
</tr>
<tr>
<td>Barbe 1996</td>
<td>0</td>
<td>10</td>
<td>0</td>
<td>10</td>
<td></td>
<td>Not estimable</td>
<td></td>
</tr>
<tr>
<td>Bott 1993</td>
<td>3</td>
<td>30</td>
<td>9</td>
<td>30</td>
<td>13.8%</td>
<td>0.33 [0.10, 1.11]</td>
<td></td>
</tr>
<tr>
<td>Brochard 1995</td>
<td>4</td>
<td>43</td>
<td>12</td>
<td>42</td>
<td>18.6%</td>
<td>0.33 [0.11, 0.93]</td>
<td></td>
</tr>
<tr>
<td>Celikel 1998</td>
<td>0</td>
<td>15</td>
<td>1</td>
<td>15</td>
<td>2.3%</td>
<td>0.33 [0.01, 7.58]</td>
<td></td>
</tr>
<tr>
<td>Conti 2002</td>
<td>6</td>
<td>23</td>
<td>5</td>
<td>26</td>
<td>7.2%</td>
<td>1.36 [0.48, 3.86]</td>
<td></td>
</tr>
<tr>
<td>Dikensoy 2002</td>
<td>1</td>
<td>17</td>
<td>2</td>
<td>17</td>
<td>3.1%</td>
<td>0.50 [0.05, 5.01]</td>
<td></td>
</tr>
<tr>
<td>Khilnani 2002</td>
<td>3</td>
<td>20</td>
<td>2</td>
<td>20</td>
<td>3.1%</td>
<td>1.50 [0.28, 8.04]</td>
<td></td>
</tr>
<tr>
<td>Plant 2000</td>
<td>12</td>
<td>118</td>
<td>24</td>
<td>118</td>
<td>36.7%</td>
<td>0.50 [0.26, 0.95]</td>
<td></td>
</tr>
<tr>
<td>Servillo 1994</td>
<td>1</td>
<td>5</td>
<td>1</td>
<td>5</td>
<td>1.5%</td>
<td>1.00 [0.08, 11.93]</td>
<td></td>
</tr>
<tr>
<td><strong>Total (95% CI)</strong></td>
<td><strong>310</strong></td>
<td><strong>312</strong></td>
<td><strong>100.0%</strong></td>
<td></td>
<td><strong>0.52 [0.35, 0.76]</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total events: 33 with NPPV, 65 with UMC

Heterogeneity: Chi² = 6.94, df = 8 (P = 0.54); I² = 0%
Test for overall effect: Z = 3.37 (P = 0.0008)

Ram, Cochrane Database of Systemic Reviews 2004
Clinical Applications
COPD Exacerbations: Intubation

<table>
<thead>
<tr>
<th>Study or subgroup</th>
<th>NPPV n/N</th>
<th>UMC n/N</th>
<th>Risk Ratio M-H,Fixed,95% CI</th>
<th>Risk Ratio M-H,Fixed,95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avdeev 1998</td>
<td>5/29</td>
<td>8/29</td>
<td>0.63 [0.23, 1.68]</td>
<td></td>
</tr>
<tr>
<td>Barbe 1996</td>
<td>0/10</td>
<td>0/10</td>
<td>0.00 [0.00, 0.00]</td>
<td></td>
</tr>
<tr>
<td>Bott 1993</td>
<td>0/30</td>
<td>2/30</td>
<td>0.20 [0.01, 4.00]</td>
<td></td>
</tr>
<tr>
<td>Brochard 1995</td>
<td>11/43</td>
<td>31/42</td>
<td>0.35 [0.20, 0.60]</td>
<td></td>
</tr>
<tr>
<td>Celikel 1998</td>
<td>1/15</td>
<td>2/15</td>
<td>0.50 [0.05, 4.94]</td>
<td></td>
</tr>
<tr>
<td>Conti 2002</td>
<td>12/23</td>
<td>26/26</td>
<td>0.53 [0.36, 0.78]</td>
<td></td>
</tr>
<tr>
<td>del Castillo 2003</td>
<td>1/20</td>
<td>3/21</td>
<td>0.35 [0.04, 3.09]</td>
<td></td>
</tr>
<tr>
<td>Dikensoy 2002</td>
<td>2/17</td>
<td>7/17</td>
<td>0.29 [0.07, 1.18]</td>
<td></td>
</tr>
<tr>
<td>Kliniani 2002</td>
<td>3/20</td>
<td>12/20</td>
<td>0.25 [0.08, 0.75]</td>
<td></td>
</tr>
<tr>
<td>Kramer 1995</td>
<td>1/11</td>
<td>8/12</td>
<td>0.14 [0.02, 0.92]</td>
<td></td>
</tr>
<tr>
<td>Plant 2000</td>
<td>18/118</td>
<td>32/118</td>
<td>0.56 [0.34, 0.94]</td>
<td></td>
</tr>
<tr>
<td>Servillo 1994</td>
<td>1/5</td>
<td>3/5</td>
<td>0.33 [0.05, 2.21]</td>
<td></td>
</tr>
<tr>
<td>Thys 2002</td>
<td>0/7</td>
<td>3/5</td>
<td>0.11 [0.01, 1.71]</td>
<td></td>
</tr>
<tr>
<td>Zhou 2001</td>
<td>7/30</td>
<td>17/30</td>
<td>0.41 [0.20, 0.85]</td>
<td></td>
</tr>
</tbody>
</table>

Total events: 62 (NPPV), 154 (UMC)
Heterogeneity: Chi² = 7.58, df = 12 (P = 0.82); I² = 0.0%
Test for overall effect: Z = 7.20 (P < 0.00001)

Ram, Cochrane Database of Systemic Reviews 2004
Clinical Applications
COPD Exacerbations: Length of hospital stay

Ram, Cochrane Database of Systemic Reviews 2004
Clinical Applications
COPD Exacerbations

• GOLD 2016
  • Clearly states NIV improves outcomes, mortality, and hospital length of stay as grade A evidence
  • Indications:
    • Respiratory acidosis (pH ≤ 7.35 and/or PaCO₂ ≥ 45 mm Hg)
    • Severe dyspnea suggestive of respiratory muscle fatigue or increased work of breathing

www.goldcopd.org
Clinical Applications

• Acute respiratory failure
  • Brief trial
  • In ARDS. . .perhaps

• Except. . .
  • Delay in intubation may worsen outcomes
  • Concern about excessive tidal volumes
Case 3

67 year old with severe COPD presented with an acute exacerbation three days ago. He was briefly tried on NIV but failed and is now intubated.

He has remained afebrile for the past 24 hours, he is awake, with strong cough and minimal tracheal secretion.
Question 3

You tried a weaning trial. On pressure support of 5 and PEEP of 5, his respiratory rate was 25 and tidal volume of 250 with oxygen saturation of 90% on 50% FiO$_2$.

What is the next best course of action?

A. Re-sedate and try tomorrow
B. Increase steroids and try tomorrow
C. Extubate
D. Extubate to NIV
### Clinical Applications

**Early use of NIV in Extubation**

#### Table 3. Outcome Variables, Length of Stay, and Causes of Death for Noninvasive Ventilation and Control Groups

<table>
<thead>
<tr>
<th>Outcome Variable</th>
<th>NIV Group (n = 79)</th>
<th>Control Group (n = 83)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respiratory failure after extubation, n (%)</td>
<td>13 (16%)</td>
<td>27 (33%)</td>
<td>0.029</td>
</tr>
<tr>
<td>Time elapsed from extubation to respiratory failure after extubation, h after extubation</td>
<td>41 ± 19</td>
<td>25 ± 21</td>
<td>0.022</td>
</tr>
<tr>
<td>Reintubation, n (%)</td>
<td>9 (11%)</td>
<td>18 (22%)</td>
<td>0.12</td>
</tr>
<tr>
<td>Main causes of respiratory failure after extubation, n*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respiratory failure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With hypercapnia</td>
<td>6</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Without hypercapnia</td>
<td>2</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Aspiration, excess respiratory secretions</td>
<td>1</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Cardiac failure</td>
<td>3</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Upper airway obstruction</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Encephalopathy</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>ICU stay, d</td>
<td>11 ± 8</td>
<td>13 ± 11</td>
<td>0.14</td>
</tr>
<tr>
<td>Hospital stay, d</td>
<td>20 ± 22</td>
<td>29 ± 18</td>
<td>0.65</td>
</tr>
<tr>
<td>ICU mortality, n (%)</td>
<td>2 (3%)</td>
<td>12 (14%)</td>
<td>0.015</td>
</tr>
<tr>
<td>Hospital mortality, n (%)</td>
<td>13 (16%)</td>
<td>19 (23%)</td>
<td>0.41</td>
</tr>
</tbody>
</table>

Causes of death within 90 d of entry into study

<table>
<thead>
<tr>
<th>Cause</th>
<th>NIV Group</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shock/multiple organ failure</td>
<td>6</td>
<td>13</td>
</tr>
<tr>
<td>Respiratory failure</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Cardiac failure/cardiogenic shock</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Cardiac arrest</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Other</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Not determined*</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

Ferrer, *AJRCCM* 2006;173:164
Clinical Applications
Extubation

Ferrer, AJRCCM 2006;173:164
Clinical Applications
Use of NIV in Weaning

<table>
<thead>
<tr>
<th>Study</th>
<th>Non-invasive weaning</th>
<th>Invasive weaning</th>
<th>Relative risk (random) (95% CI)</th>
<th>Weight (%)</th>
<th>Relative risk (random) (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chronic obstructive pulmonary disease</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nava 1998w1</td>
<td>2/25</td>
<td>7/25</td>
<td></td>
<td>6.10</td>
<td>0.29 (0.07 to 1.24)</td>
</tr>
<tr>
<td>Chen 2001w4</td>
<td>0/12</td>
<td>3/12</td>
<td></td>
<td>1.61</td>
<td>0.14 (0.01 to 2.50)</td>
</tr>
<tr>
<td>Rabie 2004w6</td>
<td>1/19</td>
<td>2/18</td>
<td></td>
<td>2.47</td>
<td>0.47 (0.05 to 4.78)</td>
</tr>
<tr>
<td>Wang 2004w7</td>
<td>1/14</td>
<td>2/14</td>
<td></td>
<td>2.53</td>
<td>0.50 (0.05 to 4.90)</td>
</tr>
<tr>
<td>Wang 2005w10</td>
<td>1/47</td>
<td>7/43</td>
<td></td>
<td>3.12</td>
<td>0.13 (0.02 to 1.02)</td>
</tr>
<tr>
<td>Zheng 2005w8</td>
<td>3/17</td>
<td>3/16</td>
<td></td>
<td>6.29</td>
<td>0.94 (0.22 to 4.00)</td>
</tr>
<tr>
<td>Zou 2006w9</td>
<td>3/38</td>
<td>11/38</td>
<td></td>
<td>9.24</td>
<td>0.27 (0.08 to 0.90)</td>
</tr>
<tr>
<td>Prasad 2008w12</td>
<td>5/15</td>
<td>9/15</td>
<td></td>
<td>19.31</td>
<td>0.56 (0.24 to 1.27)</td>
</tr>
<tr>
<td>Subtotal</td>
<td>187</td>
<td>181</td>
<td></td>
<td>50.66</td>
<td>0.42 (0.25 to 0.69)</td>
</tr>
<tr>
<td>Total events</td>
<td>16</td>
<td>44</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Test for heterogeneity $\chi^2=4.48$, df=7, $P=0.72$, $I^2=0\%$
Test for overall effect $z=3.37$, $P<0.001$

Burns, *BMJ* 2009;338:b1574
Contraindications

CONTRAINDICATIONS TO NPPV

Cardiac or respiratory arrest
Nonrespiratory organ failure
  Severe encephalopathy (e.g., GCS < 10)**
  Severe upper gastrointestinal bleeding
  Hemodynamic instability or unstable cardiac arrhythmia
Facial surgery, trauma, or deformity
Upper airway obstruction
Inability to cooperate/protect the airway
Inability to clear respiratory secretions
High risk for aspiration
Clinical Application
How to

• Decide if you will use CPAP or BPAP
  • Depends on indications

• Typically try nasal interface unless they are clearly mouth breathing
  • Full face mask may help in those with severe dyspnea but may have some difficulty if they are claustrophobic
Clinical Application
How to

• Slowly introduce the mask and the pressure
  • Some patients may need more rapid up titration of pressure
    • More flow for some who are claustrophobic
  • As you adjust the pressure, check for leaks and adjust
Clinical Application

How to

- CPAP
  - If suspect OSA
    - Use auto-titrating CPAP
      - You may need to start the minimum pressure higher
    - Consider nasal mask first
      - If claustrophobic, nasal pillows
      - Full face mask if mouth breather, or at least a chin strap
Clinical Application
How to

• CPAP
  • For CHF
  • Don’t use auto-CPAP if you suspect central sleep apnea, unless you have updated equipment
    • Pick an empiric pressure, between 7 - 10
Clinical Application
How to

• BPAP
  • Can be used with nasal pillows/masks
  • If neuromuscular weakness, keep EPAP low
  • Need EPAP high enough to keep airways open
    • If have coexisting OSA
Clinical Application
How to

• BPAP
  • Need EPAP high enough to overcome PEEPi
    • If have obstructive lung disease
    • Need to do this cautiously since they are already hyperinflated
Waterfall Theory

PEEP_i

Extrinsic PEEP < PEEP_i

PEEP_i

Extrinsic PEEP = PEEP_i

PEEP_i

Extrinsic PEEP > PEEP_i
Clinical Application

How to

• BPAP
  • IPAP should be at least 4 above EPAP
  • If hypercapnic, increase pressure support
    • Increase IPAP > EPAP
    • May also need to increase EPAP if hypercapnia is not improving
  • Can increase EPAP if hypoxemic
    • Maintain the pressure support if they are also hypercapnic
Clinical Application
How to

• BPAP
  • Need to carefully observe to make sure patient is synchronizing well with the machine
  • May take some time to ensure adequate setting
  • Consider starting BPAP in a closely monitored setting
Clinical Application
How to

• Oxygen
  • Needs to be mixed at the machine, not at the mask
  • Due to entrainment of room air, may need higher flow than when on supplemental oxygen alone
Clinical Application

How to

• Anxiety
  • Difficult to manage
  • Be cautious about using benzodiazepines
  • In the closely monitored setting, dexmedetomidine may be considered
Clinical Application
How to

• Start with IPAP 8, EPAP 4 (10/5), with supplemental oxygen
• Hold the mask on their face, before using the straps
• Assess tidal volume and patient synchrony
• Assess oxygenation and respiratory rate
• Increase IPAP to achieve higher tidal volume
  • Increase EPAP if not synchronizing
• Could try increasing respiratory rate, but may worsen synchronization
Clinical Application
How to

• BPAP
  • Check ABG within 30 minutes to ensure improvement
  • If failure to improve (either clinically or by ABG), strongly consider intubation
Side-effects

• Nasal bridge breakdown
• Bloating
• Worsening hypercapnia
• Hypotension
• Claustrophobia
• Myocardial infarction?
Keep in mind

• Respiratory therapists are key in helping find the right mask and settings
  • They may be very busy
  • They may need some oversight

• Often, we get one shot at getting patients started on NIV
Summary

• Understand there are many options of machines and masks

• In most disorders of respiratory failure, should consider NIV
  • Especially for CHF and COPD
  • Other options for hypoxic respiratory failure

• Carefully consider contraindications
Summary

• Anticipate increased time to ensure adequate setting
• Be mindful we may only have one chance to get this right
• Follow carefully and be prepared to intubate if necessary
Thank you!

park.john@mayo.edu