Non-Invasive Ventilation in Emergency Medicine

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Purpose

• Relate clinical outcomes to physiology

• Provide evidence/indications for use of NIPPV

• Discuss contra-indications

• Expand your knowledge of NIPPV/HiFLO/ApO X
Questions You Should be Able to Answer

• Who benefits from NIV and who doesn’t?

• Who does better on CPAP vs. BPAP Vs. HiFlo O2?

• When should we intubate people after a fair trial of B/CPAP?

• Can NIV techniques help me in the peri-intubation period?
### Which Patients Can Get NIV

<table>
<thead>
<tr>
<th>Room</th>
<th>Chief Complaint</th>
<th>Age</th>
<th>Sex</th>
<th>Triage</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>HTN/CHF/SOB</td>
<td>74</td>
<td>F</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>SOB multiple rib fractures</td>
<td>38</td>
<td>M</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>Lung transplant/SOB</td>
<td>66</td>
<td>M</td>
<td>3</td>
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<tr>
<td>4</td>
<td>Pedi Fever + SOB</td>
<td>9 MO</td>
<td>F</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>Fever/PNA/SOB</td>
<td>57</td>
<td>F</td>
<td>3</td>
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<tr>
<td>Resus1</td>
<td>EMS: AMS/COPD/Resp distress</td>
<td>69</td>
<td>M</td>
<td>2</td>
</tr>
<tr>
<td>Resus2</td>
<td>EMS: Sepsis/AMS/Resp distress</td>
<td>72</td>
<td>M</td>
<td>2</td>
</tr>
</tbody>
</table>

*Note: The Triage column indicates the priority level for treatment.*
What Is NIV?

- APOX
- CPAP
- Bubble CPAP
- HiFlowO2
- BiPAP
NIV: Background and Benefits

• Prevents:
  • Ventilator related complications
  • Mortality in pediatrics (sp. Bubble CPAP)

• Improves
  • Dyspnea in select CHF patient’s
  • Long-term outcomes in COPD

• Evolving evidence supporting HiFLO O2 in PNA!
CPAP: How it Works

- CPAP = EPAP = PEEP

- Stented airways
- ↑ Recruitment
- ↑ FRC + Alveolar SA
- ↑ V/Q + ↓ WOB + ↑ O2
What’s different about BiPAP/Bi-Level?

**Inspiratory PAP (PSV)**

**Expiratory PAP (CPAP)**

**Inspiration**

**Expiration**

$\text{IPAP} + \text{EPAP} = \text{BPAP}$
What’s different about BPAP/Bi-Level?

• Adds an IPAP/PS or pressure above PEEP
  • BiLevel of 10/5 adds 5 cmH20 above PEEP

• Adding PS decreases WOB and dead space

• Improves ventilation and CO2 clearance
Bubble CPAP

- CPAP = tube depth
- "Oscillatory" CPAP
- Useful <12 months
Choosing Pressure

• CPAP:
  • 1 cm H2O/10Kg,
  • Max of 10 cmH2O
  • Ex: 60 kg pt = 6 cm H2O
BPAP Settings

• Bi-level: 2 cmH20/10Kg
  • Ex: 60kg pt → start at 12

• Repeat ABG in 1 hr add 2cmH20 IPAP
  PaCO₂ > 50

• I/EPAP Max: 20/10

• Start low, titrate up
NIV-Indications

- No guidelines on indications, just know contraindications

- CPAP and Bi-Level
  - CPAP: CHF Better than BiPAP
  - COPD: BiPAP preferred 2/2 effect on CO2
  - Other indications...
Contraindications

• Absolute
  • Increased secretions; emesis
  • AMS
  • Poor mask fitting
  • Needs ET tube

• Relative:
  • Severe hypoxia/hypercapnia, P:F<200
  • Cannot tolerate mask
  • Hemodynamic instability
How PAP Works in COPD

• Overcomes loss of pulmonary elasticity

• Improvements in gas exchange

• Less hypercapnia
BPAP in COPD: Effects on WOB

- NIPPV Reduces work of breathing via:
  - Reduces PaCO2
  - Improves PaO2
  - Subsequent reduction in RR

Bouchard et al, 1995
Physiology = Clinical Outcome

• RCT 5 European centers
• N = 275, 30% severe
• Outcomes:
  • O2: 74% Intubated
  • CPAP: 26% Intubated

Brouhard et Al, 1995
NIV Vs. Usual Care: Metadata

Treatment Failure (N=529)
- NNT=5

Mortality (N=523)
- NNT=8

Intubation (N=546)
- NNT=5

Lightowler et al BMJ 2003
Predictors of Failure on BiPAP

- RR > 30
- GCS < 12
- PH < 7.25
- High APACHE II

Anton et Al, 2003
Predictors of Failure on BiPAP

- 50% failure at 2 hrs

Anton et Al, 2003
NIV in COPD

- Prevents intubation (NNT = 5)
- BiPAP likely more effective

Predictors of failure
- GCS < 12
- Apache scores > 29
- PH < 7.25
NIV for Heart Failure
NIV Indirectly Augments SV

↑ intrathoracic pressure

↓ RV filling = ↓ Preload

↓ RVV = ↓ blood to LV

Optimized Frank-Starling
NIV and the Left Heart

- ↑PEEP = ↑p™
- ↑p™ overcomes afterload

http://www.derangedphysiology.com
NIV In CHF Breaks the Failure

- Increased myocardial oxygen consumption
- Failing ischaemic left ventricle
- Pulmonary oedema
- Decreased lung compliance
- Increased workload of the left ventricle
- Increased preload due to increasingly negative intrathoracic pressure
- Increasingly negative inspiratory pressure required to ventilate
- Increased afterload due to decreased transmural pressure
- Decreased transmural pressure due to negative intrathoracic pressure
Overall Effects in Cardiogenic Pulmonary Edema

• Primary effect via increased intra-thoracic pos. pressure

• Reduces venous return (preload)

• LV Afterload reduction via augmented PTm

• Reduces cardiac work via less RVSV and LV afterload
NIPPV Prevents Death in CHF

Masip et Al. JAMA 2005
NIPPV Prevents Intubation in CHF

Figure 3. Effects of Noninvasive Ventilation on Need to Intubate

<table>
<thead>
<tr>
<th>Source</th>
<th>Continuous Positive Airway Pressure</th>
<th>Need to Intubate, No. of Events/Total No.</th>
<th>Noninvasive Ventilation</th>
<th>Favors Noninvasive Ventilation</th>
<th>Favors Control</th>
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<td>Rasran et al, 1985</td>
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<td>Lin et al, 1996</td>
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<td>Tokodo et al, 1997</td>
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<td>4/10</td>
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<td>Kelly et al, 2002</td>
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<td>Overall Category</td>
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<td>76/238</td>
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<table>
<thead>
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<th>Source</th>
<th>Noninvasive Pressure Support Ventilation</th>
<th>Need to Intubate, No. of Events/Total No.</th>
<th>Noninvasive Ventilation</th>
<th>Favors Noninvasive Ventilation</th>
<th>Favors Control</th>
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<td>Masip et al, 2000</td>
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<td>Crano et al, 2004</td>
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<tr>
<td>Overall Category</td>
<td>22/150</td>
<td>45/156</td>
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</table>

Overall: 51/389 vs. 121/394

Risk Ratio: 0.48
95% Confidence Interval: 0.30-0.75
P < 0.002

Risk Ratio: 0.43
95% Confidence Interval: 0.32-0.57
P < 0.001

Less Intubated

Masip et al, JAMA 2005
Is BPAP safe in CHF?

- Mehta et Al 1997:
  - Increased mortality in BPAP group 2/2 MI:
  - Issues in methodology and randomization
BiPAP is safe in CHF

- Belone et al. CCM 2004: RCT No risk of MI vs. CPAP
- Li et al. AMJ EM 2013: Meta Analysis: No mortality difference
Conclusions: CHF

- B or CPAP may be used for acute heart failure

- BiPAP = MI have never been replicated in the literature

- CPAP = BiPAP w/ regard to mortality
Other Emergent Indications

- Asthma
- Immunocompromised
- Palliative care
- PNA?
- Kids?
What About Asthma?

- Soroksky et. AL, Chest 2003:
  - BiPAP vs. standard therapy for asthma
    - Improved FEV1: 80% BiPAP vs. 20% standard
    - Hospitalization: 18% BiPAP vs 63% standard
  - **Bottom Line:** BiPAP is efficacious and safe but needs more research
NIV in Immunocompromise

- Reductions in Intubation and death

Antonelli et al 2000 JAMA

Hilbert et al 2001

- Benefit in Ca only
What About NIV for ARF in kids

- 2 RCT's to date!
- Indications similar to adults
- Major issues:
  - “Mask fear”
  - Patient comfort
NIV vs. Standard
Yanez Ped CCM 2008

• 32% less intubations

Bubble CPAP vs. O2
Chisti et Al Lancet 2015

• 10% less intubations
• 10% less death
NIV is Superior to standard O2

• NIV in kids >1yo reduces intubations

• Bubble CPAP/HiFLO benefits exist <14 months of age

• Use of BCPAP or HFNC results in:
  • Improved survival
  • Less intubation
Other Indications

• **Palliative care**: Levy et al. CCM 2007
  • Benefits sp. to COPD and CHF pt’s

• **Blunt chest trauma**: Hernandez et al. chest 2010
  • Prevents intubation

• **Neuromuscular disease**:  
  • Benefit in ALS and Myasthenia W/ bulbar function intact
Is NIV Indicated or Useful In PNA?

• IDSA and ATS:
  • “Cautious use of NIV”
  • Avoid altogether:
    • PaO2/FiO2 <150
    • B/L infiltrates

Image courtesy of Jack Ren, Radiopaedia.org, rID: 29090
NIV In Pneumonia: Who Fails

- Carron et al. AJCC 2010: NIV: 56% failure in CAP
- Who fails at 1 Hr post NIV:
  - PH < 7.35
  - RR > 28
  - P:F < 177
- Caroll et al ICM 2012: Worse for de Novo ARF
NIV In Pneumonia

• Not for: P:F <150 or B/L infiltrates

• If you use NIV in CAP get a 0/1hr ABG

• 1 Hr Predictors of failure:
  • Higher RR,
  • lower pH (<7.35)
  • P:F < 200

• Data shows that patients who fail do far worse
Other Diseases With Little Proven Benefit

• **ARDS/ALI**: Argawal et al. Respir Care 2010
  • 50% failure rate

• **Acute chest/SSDz**: Fartoukh et al. ICM 2010
  • No improvement in hypoxia or pain

• **Cystic Fibrosis**:  
  • Benefit in chronic RX

• Not much data in Acute disease
Hi Flow O2

- Heated/Humidified
- FIO2: 0.2-1.0
- Decreases air entrainment
- Flows: 20-60 LPM
Hi Flow O2

Image courtesy of vapotherm.com
HiFlo2: How it works

- Deadspace washout
- Decreased nasal resistance
- Decreased WOB
- Provides PEEP up to 3 cm
HiFlo Indications

- Pediatric respiratory distress
- Pre-oxygenation for RSI
- Adult Hypoxic Respiratory Failure (No AMS)
Hi Flow Equipment
Hi Flow Outcomes

• Adults: Improves outcomes in pure hypoxic RF

• Kids:
  • McKiernan J Peds 2010:
    • 14% less intubations vs. standard in bronchiolitis
  • Shibler Int. Care Med 2011
    • 20% reduction in HR/RR at 60 mins
High-Flow Oxygen through Nasal Cannula in Acute Hypoxemic Respiratory Failure

- **FLORALI trial**: HFNC at 50 LPM Vs. BiPAP Vs. NC
- **310 patient RCT**
- **Primary outcome**: Intubation
- **Secondary outcome**: Survival
Intubation Rate Lower in Sicker Patients

All Patients

P:F < 200
HiFlo Improves 90 Day Mortality in Hypoxic ARF

- Due to 3 factors:
  - O2 and Hypoxia
  - NIPPV: barotrauma
  - Secretion clearance
Who HFNC is Not For

• Those who do better on NIPPV:
  • Shock
  • COPD
  • Pulmonary edema

• 2 Hr Predictors of failure:
  • Intensive Care Med. 2011

  • Increased RR
  • Thoraco-abdominal dysynchrony
  • Drop from initial PaO2
Setting the Flow

- Neonate: 2 LPM
- Infant: 6 LPM
- Child: 20 LPM
- Adult: 60 LPM
Titration Tips

• Start at the max and decrease

• Adults: avoid hyperoxia SPO2 94-98%
  
  • Lower Mortality: Girardis et al JAMA 2016

• Infants: RR/HR is a good surrogate

• Beware the 60LPM/100%
Other uses: Apneic Oxygenation

• Prolongs time to desaturation:
How Does O2 Effect Apneic Time?

1 min
RA: 21%
O2

2 Mins
7L: 50%
FiO2

4-8 mins
15+L: 100%

Paralytic Choice Can Effect Apneic Time

4.7 mins

6 mins
Apneic O2 in a Nutshell

3 Minutes

- 96%
- 95-91%
- <90%

NRB+NC
NC+PAP
NC @ 15 LPM

Paralyze
Intubate

Preoxygenation
ApO2X Phase
Apneic Oxygenation Keys

- Denitrogenate/Preoxygenate:
  - 3 Mins O2 by NC or 8VC breaths
  - APOX: NC during intubation at >15LPM

- Preox Position: 20 degrees for alveolar recruitment
Conclusions: Benefits of NIV

- Shows benefit:
  - CHF
  - COPD
  - ARF in neuromuscular Dz., Immunocompromised, blunt

- Moderate benefit: Asthma

- No benefit/may be harmful:
  - Pneumonia → Hiflow O2 is better
  - ARDS/ALI, sickle cell
Conclusions: Selecting Candidates

- What modality:
  - CPAP for O2,
  - BPAP for CO2

- Know who fails:
  - Acidotic, High RR
  - People who don’t improve at 1 Hr

- Kids:
  - Can use standard NIV in older kids
  - Bubble CPAP saves kids <13-14 mo.
Apneic Oxygenation

• Prevents desaturation esp. in critical pt’s

• Keys:
  • Position HOB 20 degrees
  • Pre-oxygenate X 3 mins
  • Choose paralytics wisely

• Pre-oxygenation:
  • PAP + NC for <91% O2
  • NC + NRB at 15+ for O2 >91%
References


• Keenan, S. et.al. (2011). Clinical practice guidelines for the use of noninvasive positive-pressure ventilation and noninvasive continuous positive airway pressure in the acute care setting. Canadian Medical Association Journal. PMID: 21324867


So What do We do With PNA?

• Initial and 1 hr re-assessment are key!
  • Initial acidosis, AMS, Failure to improve → *Intubate*

• Know who fails: Low pH, High RR, Sicker patients

• Consider Hi Flow first instead of standard NIV unless:
  • Pre-existing COPD or pulmonary disease
  • Need for intubation