Noninvasive Ventilation for Acute Respiratory Failure- Physiology and Evidence

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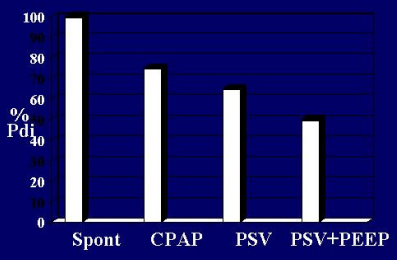
Disclosures

- Research Grants/Med Advisory Boards
  - Respironics, Inc
  - Fisher Paykel
  - Breas, Inc

Outline

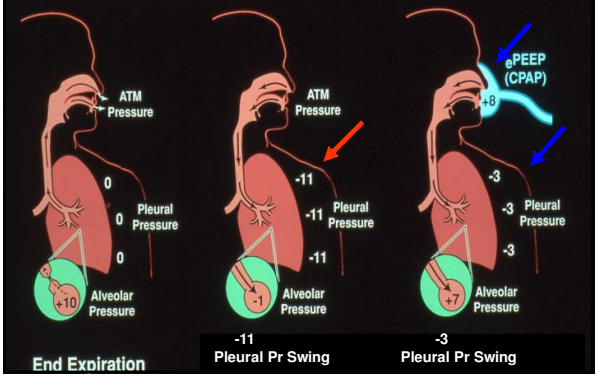
- **Acute Applications of NIV**
  - **Physiologic Basis**
  - **Evidence Base**
  - **Guidelines**
  - **Epidemiology**

Physiologic Rationale for NIV in COPD: Effect of Pressure Support plus PEEP



Appendini et al, AJRCCM 1994

Extrinsic(e) PEEP to Counterbalance Intrinsic(i) PEEP



1990s Accumulation of Evidence

- Brochard L et al, NEJM 1990
  - 12 pts, decr WOB, avoidance of intubation
- Bersten et al, NEJM 1991
  - 39 Pulm Edema pts on CPAP, intub (0 v 35%)
- Kramer N et al, AJRCCM 1995
  - 31 COPD pts, decr intubation in COPD, not non-COPD
- Brochard L et al, NEJM 1995
  - 81 COPD pts, decr intubation, (26 v 74%) decr mortality (9 v 29%)

Benefits of NIV in Acute COPD compared to Conventional Rx*

- More rapidly improves dyspnea
- More rapid ↓ RR, HR, breathing effort
- More rapid ↓ $PaCO_2$, ↑ O_2
- Lowers intubation rate (50%→20% ↓65%)
- Lowers mortality (↓55%), morbidity rate
- Less time in hospital (↓1.9d)

*Meta-analysis Quon et al,Chest'08

NIV for COPD associated with:

- Difficult weaning (to facilitate extubation)
- Pneumonia
- Extubation failure
- Do-not-intubate status
- Post-operative Respiratory Failure

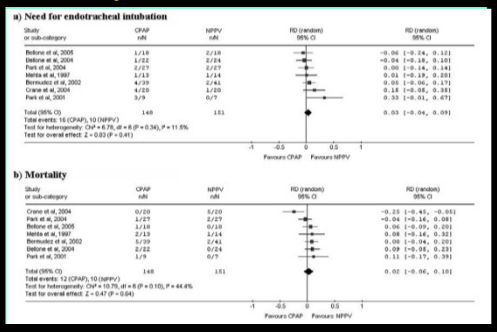
NIV for Acute Pulmonary Edema: Physiologic Rationale

- CPAP:
  - Increased FRC
  - Re-expands flooded alveoli
  - Improved oxygenation
  - Increased compliance
  - Afterload reduction - ↑ cardiac function
- Pressure Support:
  - Further reduction in work

Acute Cardiogenic Pulmonary Edema

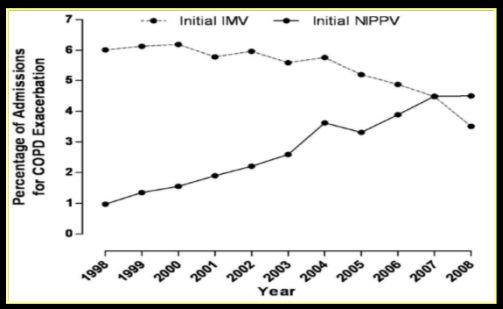
- Multiple RCTs have shown that either CPAP (10-12.5 cm H20) or BiPAP (12-15/4-5 cm H20) benefit patients compared to oxygen supplementaion alone.
- **But which is better?**

Meta-analysis: CPAP vs NIV for ACPE



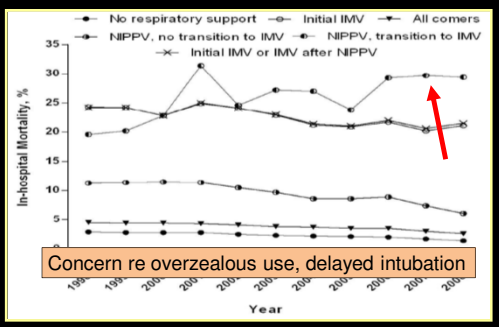
Winck et al, Crit Care 2006 10:R69

Increasing Use of NIV for COPD in US (> 7X10^6 admissions)



Chandra D et al, AJRCCM 2012

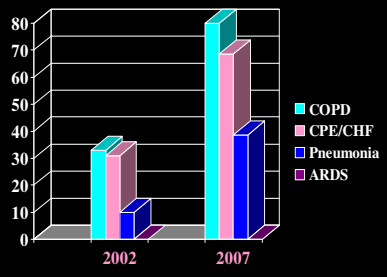
Diminishing Mortality Overall



Chandra D et al, AJRCCM 2012

Use of NIV increased for COPD, CPE and PNA (Massachusetts and Rhode Island, USA) 2002-2007

% of Vent starts for COPD Exacerbations, CPE/CHF, PNA and ARDS treated with NIV



Maheshwari V et al, Chest '06, Ozsancak Urgurlu A et al, Chest '13

Official ERS/ATS clinical practice guidelines: noninvasive ventilation for acute respiratory failure

Bram Rochwerg[1], Laurent Brochard[2,3], Mark W. Elliott[4], Dean Hess[5], Nicholas S. Hill[6], Stefano Nava[7] and Paolo Navalesi[8] (members of the steering committee); Massimo Antonelli[9], Jan Brozek[1], Giorgio Conti[9], Miquel Ferrer[10], Kalpalatha Guntupalli[11], Samir Jaber[12], Sean Keenan[13,14], Jordi Mancebo[15], Sangeeta Mehta[16] and Suhail Raoof[17,18] (members of the task force)

ERJ Respir J 2017 50:1602426

NIV: Summary of Recommendations

TABLE 2 Recommendations for actionable PICO questions

Clinical indication#	Certainty of evidence¶	Recommendation
Prevention of hypercapnia in COPD exacerbation	⊕⊕	Conditional recommendation against
Hypercapnia with COPD exacerbation	⊕⊕⊕⊕	Strong recommendation for
Cardiogenic pulmonary oedema	⊕⊕⊕	Strong recommendation for
Acute asthma exacerbation		No recommendation made
Immunocompromised	⊕⊕⊕	Conditional recommendation for
De novo respiratory failure		No recommendation made
Post-operative patients	⊕⊕⊕	Conditional recommendation for
Palliative care	⊕⊕⊕	Conditional recommendation for
Trauma	⊕⊕⊕	Conditional recommendation for
Pandemic viral illness		No recommendation made
Post-extubation in high-risk patients (prophylaxis)	⊕⊕	Conditional recommendation for
Post-extubation respiratory failure	⊕⊕	Conditional recommendation against
Weaning in hypercapnic patients	⊕⊕⊕	Conditional recommendation for

#: all in the setting of acute respiratory failure; ¶: certainty of effect estimates: ⊕⊕⊕⊕, high; ⊕⊕⊕, moderate; ⊕⊕, low; ⊕, very low.

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NIV Outcomes from LUNG SAFE

- Large observational multinational ARDS study
- 506 of 2813 (18%) ARDS pts treated with NIV
- NIV failure in 22% mild, 42% mod and 47% severe (Overall NIV Failure rate 38%)
- NIV success 16% died, NIV failure 45% died
- If PaO2/FIO2<150, mortal NIV 36% IMV 25%

Bellani G et al. AJRCCM 2016

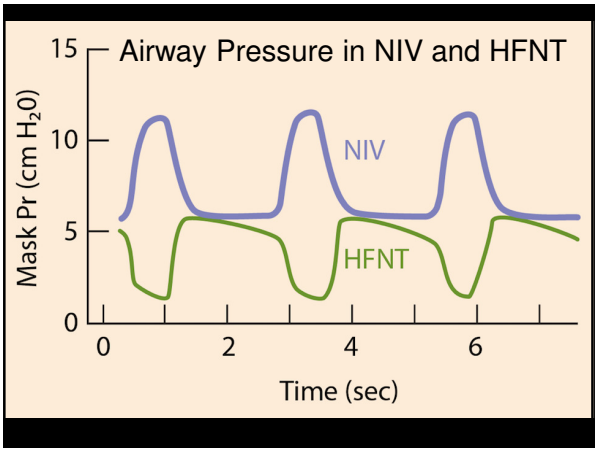
Why is NIV so challenging for ARDS/Severe Hypoxemic RF?

- Severe O2 defect – more PEEP, more leak, desaturation if mask "falls" off
- Stiff lungs – Higher insp pressure, more leak, less comfort
- High minute volumes, tachypnea – harder to meet demands, synchronize
- Sick patients – sepsis, secretions, MODS, deteriorating
- Prolonged respiratory failure

High Flow Nasal O2 (HFNO) – Role in Moderate ARDS?

Heated, humidified oxygenated gas at flows up to 80 L/min

- **Comfortable/tolerable for most patients**
- **Clears dead space in upper airway**
- **Enhances mucociliary clearance**
- **Provides PEEP - roughly 1 cm H2O for each 10 L/min flow**
- **May help to reduce work of breathing and serve as more tolerable supplement for NIV (NIV lite?)**
- **RCT of High Flow v Stnd O2 vs NIV in PNA/ARDS ↓ intub rate ↓ O2, decr 90d mortal Frat NEJM 2019**



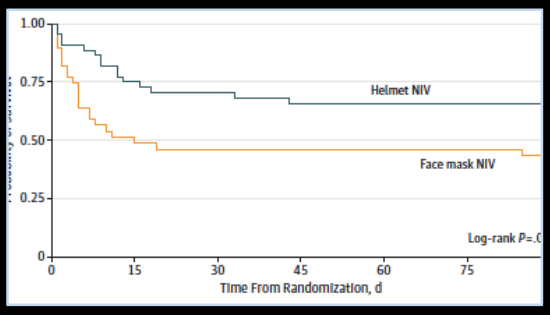
Helmet for ARDS/Pneumonia

Consec pts placed on FFM for 8 hrs, then randomized, used 2 different ventilators, stopped early,

	Helmet (8/8)	FFM(11/5)
n	44	39
PaO2/FIO2	118	144
ETT (%)	18.2	61.5*
Resp Failure (%)	38	83*
Hosp LOS (days)	10.1	15.2
90d mortality (%)	34.1	56.4*

*P<0.05 Patel B et al, JAMA 2016

Helmet for ARDS



Patel B et al, JAMA 2016

Helmet

Summary: NIV for Acute Resp Failure

- Strong physiologic and clinical evidence to support use of NIV for hypercapnic RF and cardiogenic pulm edema
- Other indications: Post-op, Post-extubation, Trauma, palliative
- Hypoxemic RF still controversial
- Use increased during “decade of NIV”
- HFNC may have advantages for AHRF