NIPPV in non COPD acute respiratory failure—current status and recent advances

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Introduction

• Noninvasive ventilation is the delivery of ventilatory support without the need for invasive artificial airway

• Based on the results of clinical trials showing improved outcomes in certain types of acute respiratory failure its use has ↑ed in recent years

Am J Respir Crit Care Med 2001; 163:540–577
Types of Noninvasive Ventilation (NIV)

- Negative Pressure Ventilation (NPV)
- Continuous Positive Airway Pressure (CPAP)
- Noninvasive Positive Pressure Ventilation (NPPV)
Negative Pressure Ventilation

• Negative pressure ventilators apply a negative pressure intermittently around the patient’s body or chest wall → iron lung or tank ventilator

• Pressure is applied intermittently to the thoracic area resulting in a pressure drop around the thorax

• Negative pressure is transmitted to the pleural space and alveoli creating a pressure gradient between the inside of the lungs and the mouth

• As a result gas flows into the lungs
Continuous Positive Airway Pressure - CPAP

• Form of noninvasive support usually applied through a mask-type device

• Does not
  – provide volume change
  – Support patient’s minute ventilation

• Often used for two different clinical situations
  – Therapeutic technique for treating OSA pt
  – Acute care facility to help improve oxygenation -> patients with acute congestive heart failure
Noninvasive Positive Pressure Ventilation

• NPPV provides positive pressure through the upper airway by some type of mask or other noninvasive interface

• Provision of inspiratory pressure support plus PEEP & is used to treat both acute and chronic respiratory failure

• In acute care setting NPPV → treat patients with acute respiratory failure

• In chronic respiratory failure → used to provide 24-hour ventilatory support
• IPAP
  – Augments tidal volume
  – Increases airway pressure
  – Decreases fatigue

• EPAP splint and maintains a fixed alveolar pressure
  – Prevents airway and alveolar collapse
  – Prevents atelectasis
  – Maintains functional residual capacity at increased levels
  – It maintains oxygenation
# NIV - evidence

**Table 1.** Noninvasive ventilation for various types of acute respiratory failure (ARF): Evidence for efficacy and strength of recommendation

<table>
<thead>
<tr>
<th>Type of ARF</th>
<th>Level of Evidence</th>
<th>Strength of Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypercapnic respiratory failure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COPD exacerbation</td>
<td>A</td>
<td>Recommended</td>
</tr>
<tr>
<td>Asthma</td>
<td>C</td>
<td>Option</td>
</tr>
<tr>
<td>Facilitation of extubation (COPD)</td>
<td>A</td>
<td>Guideline</td>
</tr>
<tr>
<td>Hypopneic respiratory failure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiogenic pulmonary edema</td>
<td>A</td>
<td>Recommended</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>C</td>
<td>Option</td>
</tr>
<tr>
<td>ALI/ARDS</td>
<td>C</td>
<td>Option</td>
</tr>
<tr>
<td>Immunocompromised</td>
<td>A</td>
<td>Recommended</td>
</tr>
<tr>
<td>Postoperative respiratory failure</td>
<td>B</td>
<td>Guideline</td>
</tr>
<tr>
<td>Extubation failure</td>
<td>C</td>
<td>Guideline</td>
</tr>
<tr>
<td>Do not intubate status</td>
<td>C</td>
<td>Guideline</td>
</tr>
<tr>
<td>Preintubation oxygenation</td>
<td>B</td>
<td>Option</td>
</tr>
<tr>
<td>Facilitation of bronchoscopy</td>
<td>B</td>
<td>Guideline</td>
</tr>
</tbody>
</table>

COPD, chronic obstructive pulmonary disease; ALI, acute lung injury; ARDS, acute respiratory distress syndrome.

a. A, multiple randomized controlled trials and meta-analyses; B, more than one randomized, controlled trial, case control series, or cohort studies; C, case series or conflicting data; b recommended, first choice for ventilatory support in selected patients; Guideline, can be used in appropriate patients but careful monitoring advised; Option, suitable for a very carefully selected and monitored minority of patients.
Hypercapnic Respiratory Failure

NIV should be considered first-line therapy in the management of ARF due to COPD exacerbations based on evidence derived from multiple randomized trials

*Lancet* 1993;341:1555–1557
*Am J Respir Crit Care Med* 1995; 151:1799–1806
NIV - Asthma

• Acute asthmatic attacks similar to exacerbations of COPD are characterised by
  – increase in inspiratory and expiratory indexes of airway obstruction
  – significant dynamic hyperinflation
  – generation of a large negative pleural pressure needed to overcome the increased end-expiratory intrathoracic pressure and airway resistance

• Progressive decline in FEV$_1$ leads to proportional increase in the inspiratory work of breathing → inspiratory muscle fatigue

• Increased physiologic dead space and ventilation perfusion mismatch lead to worsening hypoxemia with hypercarbia and respiratory failure
NIV - Asthma

• CPAP has
  – bronchodilatory effect
  – unload fatigued inspiratory muscles
  – improve gas exchange
  – prevents methacholine and histamine-induced asthma

• Noninvasive ventilatory support
  – increases tidal volume
  – Adds external PEEP to offset the intrinsic PEEP that builds up during an asthmatic attack → decreasing the work of the inspiratory muscles
NIV - Asthma

- Evidence is weaker for the use of NIV in asthma patients with acute respiratory failure

- An uncontrolled study - improved gas exchange and intubation avoided 15 of 17 patients with status asthmaticus & 100% survival

- NIV using face mask was effective in
  - correcting gas exchange abnormalities at lower inspiratory pressures (< 25 cm H2O)
  - preventing tracheal intubation

Meduri GU et al. Chest 1996
NIV - Asthma

- Randomized pilot study in 33 patients with acute asthma showed improved flow rates and decreased hospitalizations with NIV vs. sham NIV.

- NPPV using low inspiratory pressures (< 15 cm H2O) was highly effective in:
  - rapidly improving lung function
  - respiratory rate
  - decreasing hospitalization

- NIV should be restricted to carefully selected cases with optimal medical management & routine clinical use in Ac severe asthma not recommended.

Soroksky et al. Chest 2003
NIV - Asthma

• A trial of NIV can be considered in asthmatics who fail to respond adequately to initial bronchodilator therapy to
  – improve air flow obstruction
  – decrease the work of breathing

• Patients should be monitored closely and intubated promptly if there is no improvement in the first hour or two

• According to the BTS Standards of Care Committee Statements: “NPPV should not be used routinely in acute asthma, but a trial might be considered in patients not promptly responding to standard treatments”

  Thorax 2002; 57: 192–211
A prospective RCT on the efficacy of NIV in SAA

- 53 patients were randomized to NIV (n=28) and SMT (n=25)
- Median IPAP and EPAP used was 12 and 5 cm H₂O respectively
- Significant improvement in RR, FEV₁ and PaO₂-FiO₂ (but not pH and PaCO₂) in both the groups but not between the two groups
- Patients achieving a 50 % improvement in FEV₁ at one, two and four hours were greater in the NIV arm, but statistically insignificant

Agarwal R et.al submitted for publication
NIV - Asthma

- Length of ICU and hospital stay & mean doses of inhaled bronchodilators were significantly lesser in the NIV group

- 4 instances of SMT failure and all these patients improved with NIV

- Two patients in the NIV arm required invasive ventilation & no mortality in either of the arms

- Study concluded that addition of NIV to SMT is
  - likely to accelerate the improvement in lung function with requirement of lower doses of inhaled bronchodilators
  - shorten the ICU and hospital stay in patients with acute severe asthma

Agarwal R et.al submitted for publication
NIV - Asthma

• Cochrane systemic review - application of NPPV in patients suffering from status asthmaticus, despite some interesting and very promising preliminary results, still remains controversial

• Large, prospective, randomised controlled trials are needed to determine the role of NPPV in status asthmaticus

Rowe BH et al. Cochrane Database Syst Rev 2005
NIV-Weaning

Facilitating Extubation in COPD

• Supported by strong evidence

• RCT in patients with COPD and hypercapnic respiratory failure who failed a single / repeated T-piece trials → extubated to NIV or continued on invasive ventilation and weaned according to a standard pressure support protocol
  
  – an increased weaning rate at 28 days
  – decreased durations of MV and ICU stay
  – reduced rates of nosocomial pneumonia and 60-day mortality

Ferrer M et al. Am J Respir Crit Care Med 2003
NIV-Weaning

Conclusion

• patients intubated for hypercapnic respiratory failure due to COPD who fail SBT should be considered for a trial of extubation to NIV

• Approach should be reserved for patients who are
  – Good candidates for NIV
  – Able to tolerate levels of pressure support easily administered via mask (i.e., 15 cm H₂O)

• Should not have been a difficult intubation
NIV-Weaning

- Experimental RCT followed up 65 patients undergoing IMV for > 48 hours & who failed a spontaneous breathing T-piece trial

- During the trial, RR, TV, minute volume, rapid shallow breathing index, HR, ABP, & SpO₂ were measured at 1 and 30 minutes

- After failing a T-piece trial, patients were randomly divided in two groups
  - Extubated and placed on NPPV (n=28)
  - Returned to IMV (n=37)

Trevisan et al. Critical Care 2008
NIV-Weaning

• HD, post-surgery RF, & COPD aggravation were the most frequent causes of IMV use

• NPPV group had lower
  – % age of complications (28.6% versus 75.7%)
  – incidences of pneumonia /tracheotomy

• Length of stay in the ICU and mortality not statistically different with in groups

• Suggest that NPPV is a good alternative for ventilation of patients who fail initial weaning attempts & it reduces the incidence of pneumonia & the need for tracheotomy

Trevisan et al. Critical Care 2008
Meta-analysis of noninvasive weaning to facilitate liberation from mechanical ventilation

<table>
<thead>
<tr>
<th>Study Year</th>
<th>Eligibility criteria</th>
<th>Exclusion criteria</th>
<th>Exclusion criteria</th>
<th>Expiration and NIPPV</th>
<th>IPPV</th>
<th>Outcome reported</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>COPD (AE) MV &gt; 36-48 hr</td>
<td>Pneumonia, failure of a 1-hr T-piece trial</td>
<td>Cardiac arrest, diabetes mellitus, aortic aneurysm, neurologic disease, cancer, severe anemia, pneumonia, GI perforation, nausea, vomiting, persistent agitation</td>
<td>Initial PS at a slow rate PaCO₂ and pH and RR &lt; 30 breaths/min, and SBT performed daily using 1-piece or CPAP + 5 cm H₂O</td>
<td>Discontinued criteria + successful 3 hr SBT period</td>
<td>90-day mortality</td>
</tr>
<tr>
<td>1999</td>
<td>Obstructive and restrictive disease MV &gt; 48 hr</td>
<td>Screening after 48 hr MV</td>
<td>Insufficient cough, difficult intubation, swallowing disorder, bronchial constriction, lack of cooperation, recent GI surgery, recent respiratory issues</td>
<td>Initial PS to maintain RR 20 to 30 breaths/min, using foreseen 0.5-0.25 sec PEIP to offset PEEP, PS titrated by 5-3 cm H₂O, according to tolerance</td>
<td>Discontinued physician observation of 2 periods of decreased PS, ventilation permitted when 18-8 cm H₂O</td>
<td>90-day mortality</td>
</tr>
<tr>
<td>2001</td>
<td>COPD (AE) MV &gt; 48-60 hr</td>
<td>Permissive criteria</td>
<td>NA</td>
<td>Initial PS titrated to RR and ABGs, gradually decreasing to PS and PEEP</td>
<td>Discontinued criteria + successful 3 hr SBT period</td>
<td>Mortality</td>
</tr>
<tr>
<td>2000</td>
<td>ARF (AE) MV &gt; 40 breaths/min</td>
<td>Daily screening failure of 2 hr T-piece trial</td>
<td>Craniocerebral trauma, or surgery, recent upper or lower gastrointestinal surgery, tracheotomy, upper GI bleeding, excessive secretions, lack of cooperation</td>
<td>PS ventilation in ST mode delivered continuously during 24 hr</td>
<td>Discontinued after successful 2 hr SBT</td>
<td>ICU mortality, 90-day mortality</td>
</tr>
</tbody>
</table>

Karen EA et al. CAN J ANESTH, 2006
NIV-Weaning

• 5 studies enrolling 171 patients demonstrated that compared to IPPV, noninvasive weaning decreased
  – mortality (relative risk, 0.41 [95% confidence interval [CI] 0.22–0.76]),
  – VAP(relative risk, 0.28 [95% CI 0.09–0.85]) and
  – Total duration of MV (weighted mean difference, -7.33 days [95% CI -11.45 to -3.22 days]).

• Conclusions –
  – Noninvasive weaning demonstrated a consistent positive effect on mortality
  – NPPV to facilitate weaning with predominately COPD, is associated with promising, but insufficient, evidence of net clinical benefit

Karen EA et al. CAN J ANESTH, 2006
Hypoxemic Respiratory Failure

• Hypoxemic ARF is defined by a PaO$_2$/ FIO$_2$ ratio < 300 while breathing oxygen through venturi mask and a variety of different non-COPD etiologies
**NIV-CPE**

- Use of NIV or CPAP in patients with CPE is supported by multiple RCTs.

- Physiologic benefit from NIV or CPAP in these patients is likely due to:
  - Increase in FRC that reopens collapsed alveoli and improves oxygenation $\rightarrow$ increases lung compliance and reduces work of breathing.
  - Increased intrathoracic pressure leading to improve cardiac performance by decreasing ventricular preload and afterload.

- Meta-analyses have shown equivalent reductions in intubation and mortality rates with CPAP and NIV.

  *JAMA 2005; 294:3124–3130*
  *Crit Care 2006; 10:R69*
<table>
<thead>
<tr>
<th>Source</th>
<th>Location</th>
<th>Sample Size</th>
<th>Mask</th>
<th>CPAP, cm H₂O</th>
<th>IPAP/EPAP, cm H₂O</th>
<th>Primary Outcomes</th>
<th>Other Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Häkkinen et al.²⁰ 1986</td>
<td>ICU in Finland</td>
<td>40</td>
<td>Full face</td>
<td>10</td>
<td></td>
<td>Clinical outcomes</td>
<td></td>
</tr>
<tr>
<td>Bersten et al.²¹ 1994</td>
<td>ICU in Australia</td>
<td>40 (39)</td>
<td>Full face</td>
<td>10</td>
<td></td>
<td>Intubation</td>
<td></td>
</tr>
<tr>
<td>Lin et al.²² 1996</td>
<td>ICU in Taiwan</td>
<td>100</td>
<td>Full face</td>
<td>2.5-12.5</td>
<td></td>
<td>Intubation</td>
<td>Swan-Ganz catheterization</td>
</tr>
<tr>
<td>Takeda et al.²³ 1997</td>
<td>ICU in Japan</td>
<td>30 (29)</td>
<td>Full face or nasal</td>
<td>4-10</td>
<td></td>
<td>Laboratory parameters</td>
<td>Measurement of plasma endothelin 1</td>
</tr>
<tr>
<td>Kelly et al.²⁴ 2002</td>
<td>ED and ICU in the United Kingdom</td>
<td>58</td>
<td>Full face</td>
<td>7.5</td>
<td></td>
<td>Clinical outcomes Laboratory parameters</td>
<td>Measurement of plasma neurohormonal concentrations</td>
</tr>
<tr>
<td>L'Hir et al.²⁵ 2004</td>
<td>4 EDs in France</td>
<td>89</td>
<td>Full face</td>
<td>7.5</td>
<td></td>
<td>48-h mortality</td>
<td>Elderly patients (≥75 y)</td>
</tr>
</tbody>
</table>

**Noninvasive Pressure Support Ventilation vs Conventional Oxygen Therapy**

<table>
<thead>
<tr>
<th>Source</th>
<th>Location</th>
<th>Sample Size</th>
<th>Mask</th>
<th>CPAP, cm H₂O</th>
<th>IPAP/EPAP, cm H₂O</th>
<th>Primary Outcomes</th>
<th>Other Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Masip et al.²⁶ 2000</td>
<td>ICU in Spain</td>
<td>40 (37)</td>
<td>Full face</td>
<td>20/5, Mean</td>
<td></td>
<td>Intubation Resolution time</td>
<td>IPAP was adjusted to tidal volume</td>
</tr>
<tr>
<td>Levitt²⁷ 2001</td>
<td>ED in the United States</td>
<td>36</td>
<td>Full face or nasal</td>
<td>8/3 Initial</td>
<td></td>
<td>Intubation</td>
<td>Prematurely interrupted when the study by Mehta et al²⁸ was published</td>
</tr>
<tr>
<td>Nava et al.²⁹ 2003</td>
<td>5 EDs in Italy</td>
<td>130</td>
<td>Full face</td>
<td>14.5/6.1, Mean</td>
<td></td>
<td>Intubation</td>
<td>Post hoc analysis in hypercapnic patients</td>
</tr>
</tbody>
</table>

**Trials With 3 Study Groups**

<table>
<thead>
<tr>
<th>Source</th>
<th>Location</th>
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<th>IPAP/EPAP, cm H₂O</th>
<th>Primary Outcomes</th>
<th>Other Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Park et al.³⁰ 2001</td>
<td>ED in Brazil</td>
<td>26</td>
<td>Full face and nasal</td>
<td>5-12.5</td>
<td></td>
<td>Intubation</td>
<td>Full-face mask for CPAP and nasal for NIPSV</td>
</tr>
<tr>
<td>Crane et al.³¹ 2004</td>
<td>2 EDs in the United Kingdom</td>
<td>60</td>
<td>Full face</td>
<td>10</td>
<td>15/5 Fixed</td>
<td>Successes in ED (7 h) In-hospital mortality</td>
<td>Prehospital nil per os therapy evaluated</td>
</tr>
<tr>
<td>Park et al.³² 2004</td>
<td>ED in Brazil</td>
<td>83 (80)</td>
<td>Full face</td>
<td>10 Initial up to 16</td>
<td>15/10 Initial</td>
<td>Intubation</td>
<td></td>
</tr>
</tbody>
</table>

**Continuous Positive Airway Pressure vs Noninvasive Pressure Support Ventilation**

<table>
<thead>
<tr>
<th>Source</th>
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<th>Primary Outcomes</th>
<th>Other Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mehta et al.³³ 1997</td>
<td>ED in the United States</td>
<td>27</td>
<td>Nasal and full face</td>
<td>10</td>
<td>15/5 Fixed</td>
<td>Intubation Physiological improvement</td>
<td>Prematurely stopped for Higher rate of AMI in NIPSV group</td>
</tr>
<tr>
<td>Bellone et al.³⁴ 2004</td>
<td>ED in Italy</td>
<td>36</td>
<td>Full face</td>
<td>10</td>
<td>15/5 Initial</td>
<td>AMI</td>
<td>Study restricted to patients with hypercapnia</td>
</tr>
<tr>
<td>Bellone et al.³⁵ 2005</td>
<td>ED in Italy</td>
<td>46</td>
<td>Full face</td>
<td>10</td>
<td>15/5 Initial</td>
<td>Resolution time</td>
<td>Primary end point was AMI rate Cny nonischemic APE</td>
</tr>
</tbody>
</table>

Abbreviations: AMI, acute myocardial infarction; APE, acute pulmonary edema; CPAP, continuous positive airway pressure; ED, emergency department; EPAP, positive expiratory airway pressure (equivalent to CPAP); ICU, intensive care unit; iPAP, inspiratory positive airway pressure; NIPSV, bilevel noninvasive pressure support ventilation.

Numbers in parentheses denote the number of patients finally included after withdrawals.

Masip J et al. JAMA 2005
NIV-CPE

- Meta-analysis reviewed short-term effect of NIV on major clinical outcomes

- NIV reduces the need for intubation and mortality in patients with acute CPE

- Although the level of evidence is higher for CPAP, there are no significant differences in clinical outcomes when comparing CPAP vs NIPSV

Masip J et al. JAMA 2005
NIV-CPE

• Several studies have shown more rapid reductions in respiratory rate and dyspnea with NIV than with CPAP alone


• NIV or CPAP can be used to treat CPE with equal success

• Some recommend starting with CPAP, because it is a simpler & potentially less expensive therapy, with pressure support added if patients remain dyspneic or hypercapnic on CPAP alone
NIV-CPE

Metaanalysis including 16 RCT. Concluded that

• NIV improves haemodynamics and respiratory parameters along with conventional treatment

• CPAP decreases intubation rate and improves survival (NNT 7 and 8)

• Decreased use IMV, shorter ICU stay & hospital stay and reduced mortality in selected cases

• Insufficient evidence for use of BiPAP except hypercapnic CPE

• BiPAP needs further evaluation in CPE

Agarwal R et al. Postgrad Med J 2005
NIV-CPE

- Study to determine whether
  - NIV reduces mortality
  - Important differences in outcome associated with the method of treatment (CPAP or NIPPV)
- Multicenter, open, prospective RCT, patients were assigned
  - standard $O_2$ therapy,
  - CPAP (5 to 15 cm of water)
  - NIPPV (IPAP, 8 to 20 cm of $H_2O$; EPAP, 4 to 10 cm of $H_2O$)
- The primary end point
  - comparison between NIV & standard $O_2$ therapy was death within 7 days after the initiation of treatment
  - comparison between NIPPV and CPAP was death or intubation within 7 days

NIV-CPE

• 1069 patients included. standard oxygen therapy (367 patients), CPAP (346 patients), or NIPPV (356 patients)

• No significant difference in 7-day
  – mortality
  – combined end point of death or intubation between the NIV groups

• NIV was associated with greater mean improvements at 1 hour of treatment in patient-reported
  – Dyspnea, heart rate, Acidosis & Hypercapnia

• Conclusion - in acute CPE, NIV induces a more rapid improvement in respiratory distress and metabolic disturbance than does standard O₂ therapy but has no effect on short-term mortality

NIV-CPE

• Systematic review - effectiveness & safety of NIPSV as compared to CPAP in CPE

• 10 studies were included. NIPSV performed similar to CPAP in decreasing
  – intubation rates, hospital mortality & occurrence of myocardial infarction

• Results were similar for the type of pressure therapy (fixed vs. variable) except for myocardial infarction, which was more frequent in the fixed pressure NIPSV arm

• Conclusion - NIPSV appears to be as safe and efficacious as CPAP, if titrated rather than fixed pressures are employed

NIV-CPE: Concrane review

- Data from RCTs have demonstrated that NPPV (CPAP and bilevel NPPV) is effective in reducing hospital mortality, intubation rate and ICU length of stay.

- NPPV resulted in faster improvement and was better tolerated than standard medical care.

- Meta-analysis did not demonstrate an increase in the incidence of adverse events or AMI during & after NPPV.

*Vital FMR et al. Cochrane Database of Systematic Reviews 2008*
NIV-CPE : Concrane review

• CPAP should be considered as first option as evidence for BiPAP remains inconclusive due to insufficient patient numbers recruited to the studies to detect statistical power to define its effectiveness

Implications

• Further studies are required to reduce uncertainty regarding length of hospital stay, long-term mortality, costs and the time required to manage NPPV

• Additional research is required to elucidate if
  – hypercapnic patients with ACPE may benefit to a greater extent than non-hypercapnic patients
  – bilevel NPPV confers additional benefit compared to CPAP

_Vital FMR et al. Cochrane Database of Systematic Reviews 2008_
NIV-pneumonia

• Challenge to treat noninvasively and has been identified as a risk factor for NIV failure
  
  *Intensive Care Med 2001; 27: 1718–1728*

• Cohort study
  – 2/3rd of patients with severe CAP required intubation
  – Successful NIV had very good outcomes

  *Intensive Care Med 2001; 27:812–821*

• An RCT on patients with severe CAP showed that NIV reduced intubation rates, ICU length of stay, and 2-month mortality rate, but only in the subgroup with underlying COPD

  *Am J Respir Crit Care Med 1999; 160:1585–1591*
NIV-pneumonia

• RCT on patients with hypoxemic respiratory failure showed that NIV reduced the need for intubation among patients with pneumonia (26% vs. 73% in the conventional therapy group)

• Reasons
  – patients from this study were more severely hypoxemic & NIV may be a significantly better support than oxygen therapy alone
  – subset of patients receiving NIV in a previous study were more seriously ill than those from the control group, as assessed by higher APACHE -II score

Ferrer M et al. Am J Respir Crit Care Med 2003
NIV-pneumonia

- RCT testing NIV as an alternative to IMV in patients with various types of ARF found that subgroup with pneumonia did very poorly, with all 8 patients randomized to NIV requiring intubation

  *Honrubia T et al. Chest 2005*

- Scant and conflicting data do not support the routine use of NIV in patients with severe pneumonia, with the exception of patients with underlying COPD

- Cautious trial of NIV may be considered in patients with pneumonia, but they need careful monitoring, because the risk of failure is high
NIV-ALI/ARDS

- Studies on NIV to treat ALI and ARDS have reported failure rates ranging from 50% to 80%

- Independent risk factors for NIV failure in this group of patients include severe hypoxemia, shock, and metabolic acidosis

  *Crit Care 2006; 10:R79*

- Prospective multicenter survey found that when NIV was used as first-line therapy for selected ALI/ARDS patients (Excluding 2 organ failures, HD instability, or encephalopathy) 54% avoided intubation and had excellent outcomes

  *Crit Care Med 2007; 35:18–25*
NIV-ALI/ARDS

• Predictors of NIV failure were
  – Simplified Acute Physiology Score > 34
  – PaO$_2$/FIO$_2$ <175 after the first hour of therapy

• NIV cannot be recommended as routine therapy for ALI/ARDS but data support a cautious trial in highly selected patients with a
  – Simplified Acute Physiology Score < 34 and
  – Readiness to promptly intubate if oxygenation fails to improve sufficiently within the first hour
NIV-ALI/ARDS

• Meta-analysis: aim to assess the effect of NIV on the rate of endotracheal intubation and ICU mortality

• Addition of NIV to standard care in the setting of ARDS
  – Did not reduce the rate of endotracheal intubation (absolute risk reduction (RR) 13.5%, 95% confidence interval (CI) 5.2% to 31.3%)
  – No effect on ICU survival

• Analysis was limited by the presence of significant heterogeneity; hence large randomized controlled trials are required to settle this issue

Agarwal R et al. Respiratory Medicine 2006
NIV-ALI/ARDS

- Prospective observational study to determine the outcomes of NIPPV & factors associated with NIPPV failure in patients with AHRF

- 40 patients - 21- ALI/ARDS & 19- AHRF due to other causes were initiated on NIPPV

- After 1 hour there was a significant ↓ in RR & HR with ↑ in pH and PaO₂ levels

- No difference in improvement of clinical and blood gas parameters between the two groups

- NIPPV failures, the mean ICU and hospital stay, and the hospital mortality were similar in the two groups

Agarwal R et al. Respiratory Care 2009. In press
NIV-ALI/ARDS

• Conclusion - NIPPV should be judiciously used in patients with AHRF as failure rate are high (57% in ALI/ARDS group)

• NIPPV offers ventilatory support with an advantage of reduced incidence of nosocomial pneumonia and reduced ICU stay and overall hospital costs

• NIPPV must be applied early and patients monitored closely in intensive care setting so that endotracheal intubation can be carried out without any delay

• A low baseline PaO$_2$-FiO$_2$ ratio was associated with NIPPV failure

Agarwal R et al. Respiratory Care 2009. In press
NIV- Immuno-compromised Patients

• RCTs in recipients of solid-organ or bone-marrow transplants who developed hypoxemic respiratory failure have found
  – decreased intubation and ICU mortality rates
  – shorter ICU stay
in patients treated with NIV as compared with conventional therapy

  *JAMA 2000; 283:235–241*

• Similar findings have been reported in a nonrandomized study for AIDS patients

  *Intensive Care Med 2002; 28:1233–1238*
NIV- Immuno-compromised Patients

• The reduced mortality is likely related to reduced infectious complications associated with NIV use compared with endotracheal intubation
  – VAP
  – Other nosocomial infections
  – Septic shock


• Data support NIV as the preferred initial ventilatory modality to avoid intubation and its associated risks
NIV-Postoperative Respiratory Failure

- Benefit in the postoperative period when used prophylactically after major abdominal surgery or thoracoabdominal aneurysm repair

- CPAP (10 cm H2O) reduces the incidence of hypoxemia, pneumonia, atelectasis, and intubations compared with standard treatment

- Only RCT of NIV in the postoperative setting, patients with hypoxemic respiratory failure after lung resection had reduced intubation and mortality rates compared to standard management

*Respir Crit Care Med 2001; 164:1231–1235*
NIV- PERF

- Evidence-based guidelines recommend a SBT to determine whether mechanical ventilation can be successfully discontinued & with this approach, the documented need for reintubation ranges from 13 to 19 %

  Am J Respir Crit Care Med 1999;159:512-8

- Extubation failure is associated with high morbidity and mortality

- NIV has been suggested as a way to avoid re-intubation and improve outcomes
**NIV- PERF**

- RCT found no reduction in reintubations among patients who developed respiratory distress within 48 hrs of extubation
  - Few COPD patients included
  - Pressure support used may have been subtherapeutic

  *Keenan SP et al. JAMA 2002*

- RCT attempted to prevent extubation failure by starting NIV / ST as soon as patients developed signs of extubation failure

- NIV fail to reduce reintubations & was associated with increased ICU mortality - related to delays in needed reintubation

- Only 10% of patients in this trial had COPD

Two RCTs involving pt at high risk for extubation failure found that NIV reduced the need for reintubation and ICU mortality & hypercapnic subgroup were most benefited

Ferrer M et al. Am J Respir Crit Care Med 2006

Data support the use of NIV in patients at high risk of extubation failure → COPD / CHF / hypercapnia

Concluded: early indiscriminate use in all patients with risk factors is discouraged & monitored closely to avoid needed intubation
NIV- PERF

- Meta-Analysis - 4 studies were included, 2 each for established PERF & “at risk” for PERF

- NPPV, compared to the SMT in PERF did not decrease the
  - Re-intubation rate /ICU mortality

- High risk for developing PERF, NPPV decreased
  - Re-intubation rate /ICU mortality
  **but not the hospital mortality**

- Conclusion:
  - NPPV should be used judiciously, if at all, in patients with PERF
  - promising as a prophylaxis to prevent re-intubation in patients “at risk” for developing PEFR

Agarwal R et al. Respir Care 2007
### Table 4. Practical Approach to the Use of NPPV in the Postextubation Setting

**NPPV in Patients At Risk for Postextubation Respiratory Failure**

(Preferred approach for the use of NPPV in the postextubation setting)

- Identify high-risk features
  - Elderly patients (age > 65 y)
  - More than one consecutive failure of weaning trial
  - Chronic heart failure
  - $P_{aCO_2} > 45$ mm Hg after extubation
  - More than one medical/surgical co-morbid illness
  - Poor cough reflex
  - Upper-airways stridor at extubation that does not require immediate reintubation
  - APACHE II score > 12 on the day of extubation
  - Severely obese patients (body mass index > 35 kg/m²)

**NPPV in Established Postextubation Respiratory Failure**

- Use judiciously
- Likely to benefit selected patients (eg, acute COPD, hypercapnic pulmonary edema)
- Trial of NPPV for 2 hours
- Close monitoring of respiratory, cardiovascular and arterial blood gas variables
- Facilities for intubation and invasive ventilation readily available

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*NPPV = noninvasive positive-pressure ventilation

APACHE - Acute Physiology and Chronic Health Evaluation

COPD = chronic obstructive pulmonary disease*
NIV- Palliative Care and Do-Not-Intubate Status

• Prospective cohort series of 114 patients with acute respiratory failure and a status of do not intubate

• 43% of the patients survived the hospitalization

• CPE & COPD had hospital survival rates 50%

• Presence of a cough and an awake mental status had favorable prognosis

Levy MM et al. Crit Care Med 2004
NIV- Palliative Care and Do-Not-Intubate Status

• Prospective cohort series showed
  – favorable success rates in do not intubate patients with COPD and CPE
  – high failure rate in patients with hypoxemic respiratory failure / post-extubation failure / end-stage cancer

  *Schettino G, Crit Care Med 2005*

• Depending on patient and/or family wishes, a trial of NIV can be considered in do-not intubate patients, but the goals of therapy should be clear

  *Curtis RJ et al. Crit Care Med 2007*
NIV- Palliative Care and Do-Not-Intubate Status

Goal of therapy

• If the patient and/or family desire prolonged survival\rightarrow use should be reserved primarily for COPD and CHF patients

• If is palliative, to relieve dyspnea, or to delay death so that affairs can be settled then NIV can be used for other diagnoses as well

• Should be reassessed frequently and stopped if the goal of palliation is not being met
NIV - Flail chest

- prospective, randomised study of CPAP via a face mask to compared with IPPV with ETI in 52 patients with flail chest

- Nosocomial infection diagnosed in 10 of 21 patients in the ET group, but only in 4 of 22 in the CPAP group (p < 0.001)

- Mean PO$_2$ was significantly higher in the ET group in the first 2 days but no significant differences in length of ICU stay

- 20 CPAP patients survived, but only 14 of 21 intubated patients who received IPPV (p < 0.01)

- study supports the application of CPAP as a first line of treatment for flail chest caused by blunt thoracic trauma

NIV - Other ICU Applications

Preoxygenation Before Intubation

• Critically ill patients with AHRF are at high risk of $O_2$ desaturations during intubation

• RCT of such patients showed that pre-oxygenation with NIV before intubation resulted in
  – improved oxygen saturation during and after intubation
  – decreased the incidence of oxygen desaturations below 80% during intubation

  *Am J Respir Crit Care Med 2006; 174:171–177*

• Approach is promising & needs further studied before routine use can be recommended
NIV-FOB

- RCT has shown that CPAP alone (up to 7.5 cm H2O) improves oxygenation and reduces postprocedure respiratory failure in patients with severe hypoxemia
  
  *Am J Respir Crit Care Med 2000; 162:1063–1067*

- RCT of 26 patients with hypoxemia (PaO2/FIO₂ ratio < 200 NIV
  - increased PaO2/FIO2 by 82%
  - 10% worsening in the conventional O₂ therapy

- NPPV is superior to conventional O₂ supplementation in preventing gas-exchange deterioration during FOB with better hemodynamic tolerance
  
  *Chest 2002; 121:1149–1154*
NIV- FOB

• Successful bronchoscopy during NIV also has been reported in hypercapnic COPD patients with pneumonia

• NIV improved oxygen saturation, and all 10 patients tolerated the procedure without complications

  *Ann Fr Anesth Reanim* 2000; 19:231–236

• Evidence supports the use of NIV during FOB when risks of intubation are high → immunocompromised / bleeding diatheses

• Be prepared for the possibility of emergent intubation
Conclusion

• Strong evidence from RCT to supports the use of NIV in ARF to prevent endotracheal intubation in pt
  – COPD exac.
  – ACPE
  – Immunocompromised pt.
  – facilitate extubation in COPD pt.

• NIV should be contemplated in patients
  – postoperative respiratory failure
  – high risk for PEFR who are otherwise good candidates for NIV
  – preoxygenating critically ill patients with hypoxemia before intubation
Conclusion

• NIV can be considered in patients
  – asthma exacerbations
  – Pneumonia
  – ALI/ARDS
    supporting evidence is fairly weak
• Patients should be monitored closely for signs of NIV failure until stabilized

• Should be intubated promptly at failure before a crisis develops

• Application of NIV by a trained and experienced ICU team, with careful patient selection, should optimize patient outcomes