Noninvasive Ventilation: Update On Uses For The Critically Ill Patient

Abstract

Noninvasive ventilation (NIV) is a method of delivering oxygen by positive pressure mask that allows the clinician to postpone or prevent invasive tracheal intubation in patients who present to the emergency department (ED) with acute respiratory failure (ARF). There are 2 primary modalities of NIV: continuous positive airway pressure (CPAP) and bi-level positive pressure ventilation (BPAP) where the inspiratory positive airway pressure (IPAP) is higher than the expiratory positive airway pressure (EPAP). Continuous positive airway pressure appears to be more effective in reducing the need for tracheal intubation and possibly mortality in patients presenting with acute cardiogenic pulmonary edema (ACPE). Bi-level positive pressure ventilation appears to be more effective in reducing mortality and the need for tracheal intubation in patients with an acute decompensation of chronic obstructive pulmonary disease (COPD). Proper patient selection is critical in the use of NIV for ED patients. They must be able to cooperate with the respiratory therapist and tolerate the often uncomfortable nasal or face mask. The emergency clinician must be vigilant for signs of clinical deterioration in these patients as they may need an emergent definitive airway placed. This issue of EMCC examines the evidence supporting the use of NIV in various causes of ARF and reviews potential complications.
Case Presentation

The triage nurse calls you to the resuscitation room where you find a morbidly obese male who is gasping for air and is cool, pale, and diaphoretic. He is seated in the tripod position with nasal flaring, pursed-lip breathing, and rales to the apices, and he is speaking in 1-2 word sentences. His blood pressure is 240/160. EMS providers have given sublingual nitroglycerin but were unable to obtain IV access and have therefore not given furosemide. You realize that attempting tracheal intubation on this patient is a recipe for disaster. You have used NIV for patients with COPD, but you haven't tried it in patients with ACPE. You page the respiratory therapist to bring the noninvasive ventilator, hoping that NIV will help the patient avoid the need for a difficult intubation. The respiratory therapist asks whether you want bi-level NIV or CPAP. You are not sure, so you ask the respiratory therapist which modality she believes is best. She recommends CPAP but wants to know what pressure to deliver. Again you defer to her knowledge, and she replies “10 cm H₂O.” Finally, she wants to know whether you prefer a nasal mask, a face mask, or a helmet. You reply: “Whatever you think is best is fine with me.” As you closely monitor the patient on NIV, you set up for RSI, just in case.

Introduction

Acute respiratory failure is encountered in the prehospital setting, the ED, the medical wards, and the intensive care unit (ICU). In these challenging clinical scenarios, NIV can provide emergency clinicians with a promising treatment modality for acutely dyspneic patients. While tracheal intubation is considered the definitive method of airway control, this intervention is associated with additional risks and morbidity, related both to induction and tube placement, as well as ventilator-associated complications. While intubation is often instinctual for emergency clinicians confronted with a patient in respiratory failure, accumulating evidence suggests that NIV can decrease the need for tracheal intubation, decrease hospital length of stay, and save lives.

Despite this, NIV is a temporizing measure that must be used selectively. Patients must be closely monitored to detect failure of therapy so that more definitive management is not delayed. Acute exacerbations of asthma and/or COPD and ACPE are 2 of the diagnoses that appear to benefit the most from NIV.

The terminology used to describe NIV (Table 1) can be confusing, a fact that can interfere with communication between emergency clinicians and respiratory therapists, complicating the prompt application of time-sensitive therapy. In this article, the term NIV will be used routinely to refer to all modes of noninvasive ventilation.

It is critical to recognize the patient in whom it is safe to try NIV and to avoid NIV in the patient who needs immediate tracheal intubation. In this issue of EMCC, we will examine the evidence and various recommendations for the use of NIV in a variety of patient presentations.

Indications For Noninvasive Ventilation In Acute Respiratory Failure

There is no clear consensus on the indications for NIV in the various forms of ARF, and each study has unique inclusion and exclusion criteria. A simple way to approach the use of NIV in ARF is to assess for the presence of certain commonly accepted absolute contraindications. (See Table 2.) Unfortunately, there is no clear threshold for determining who needs immediate intubation. In the absence of contraindications, many dyspneic patients may be suitable candidates for a trial of NIV. Furthermore, in those patients needing definitive airway control, some authors have suggested that NIV may be useful in the preoxygenation phase of rapid sequence intubation (RSI). Note that a blood gas result may not return fast enough to guide decision-making.

<table>
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<th>Table 1. Noninvasive Ventilation Glossary</th>
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<tr>
<td><strong>ACPE</strong></td>
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<td><strong>ARF</strong></td>
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<td><strong>BPAP</strong></td>
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<td><strong>IPAP</strong></td>
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<td><strong>NIV</strong></td>
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<td><strong>PEEP</strong></td>
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<td><strong>Pressure Support</strong></td>
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<td><strong>VE</strong></td>
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<td><strong>VT</strong></td>
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Relative Contraindications

- Past facial surgery precluding mask fitting
- Excess respiratory secretions and risk of vomiting and aspiration
- Need for immediate endotracheal intubation
- Decreased level of consciousness
- Hemodynamic instability
- Severe hypoxia and/or hypercapnia, PaO₂/FiO₂ ratio of < 200 mm Hg, PaCO₂ > 80 mm Hg
- Poor patient cooperation
- Lack of trained or experienced staff

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Critical Appraisal Of The Literature

Ovid MEDLINE® and PubMed were searched for the best literature pertaining to NIV in ARF from 1950 to the present. The Cochrane Library, CINAHL, and EMBASE were also searched. Over 300 articles were retrieved, and the references from relevant articles were searched for any articles that the search may have missed. In addition, the National Guideline Clearinghouse (www.guidelines.gov) was searched for NIV guidelines pertinent to the patient with acute respiratory distress. (See Table 3 on page pages 4 & 5.)

When reviewing the sizable literature on NIV, it is important to remember an issue that makes the interpretation of results difficult. The point at which an eligible patient is enrolled in an NIV study is challenging to standardize. Studies that compare NIV with emergent intubation can suffer from confounding by indication. In other words, the intubated group is often sicker at baseline and may be more likely to have increased morbidity and mortality than the NIV group. However, as Voltaire said, “the perfect is the enemy of the good.” The evidence base for NIV in various indications and for its use in the ED setting is far from complete. Readers are encouraged to tread cautiously through the dense thicket of literature as it pertains to the acutely dyspneic patient in the ED.

In addition to the difficulty in choosing eligible patients and comparing groups with equal chances of outcomes, it is essential to agree on relevant outcomes. Published outcomes range from decreased mortality to increased comfort of breathing. Additional possibilities include decreased respiratory rates, ease of breathing, decreased work of breathing, improved patient comfort, rates of tracheal intubation, ICU length of stay, and improvement in blood gases. Finally, is the timing of NIV important? Does faster door-to-mask time improve outcomes? This review of the existing data will take all of these considerations into account.

Going Deeper: How Noninvasive Ventilation Works

In acute respiratory failures of any etiology, the patient is at risk of hypoxic cardiac arrest. Historically, if these patients did not improve with a 100% nonrebreather mask, the clinician prepared for RSI. Noninvasive ventilation provides the clinician an opportunity to avoid tracheal intubation with its inherent complications, including hypoxemia due to prolonged attempts, esophageal intubation, dental or airway trauma, loss of protective reflexes with aspiration, and barotrauma. Nasal intubation, an occasional alternative to RSI, can result in sinusitis and posterior epistaxis.

In simple terms, the various forms of NIV involve a pressurized oxygen/air mixture delivered by a mechanical ventilator through several types of mask. When a fixed pressure is used, this is referred to as CPAP. Alternatively, this fixed EPAP can be combined with a higher IPAP that is triggered by the patient’s inspiratory effort. The difference between EPAP and IPAP, called pressure support, augments ventilation and reduces work of breathing, both of which can reverse hypercapnic respiratory failure. This mode is called bi-level positive airway pressure, which is commonly referred to as BiPAP, although this is a proprietary name.

Noninvasive ventilation improves lung mechanics by improving laminar airway flow by stenting closed airways or semi-obstructed airways thus decreasing atelectatic alveoli, improving pulmonary compliance, and reducing the work of breathing. Continuous positive airway pressure appears to mediate its therapeutic effects in ACPE through several interesting mechanisms. Contrary to popular belief, NIV does not simply force edema fluid out of flooded alveoli. Rather, the effects are due to the addition of positive pressure to the thoracic compartment, resulting in both preload and afterload reduction. In a study of acute lung injury (ALI) in pigs, Carvalho et al used invasive monitoring and computed tomography scanning to determine that improvements in oxygenation in pressure support ventilation were due to redistribution of pulmonary blood flow rather than recruitment of dependent zones. In addition, positive airway pressure reduces venous return to the heart. In patients without congestive heart failure (CHF), this decrease in preload may be clinically insignificant. In one study of 19 patients with COPD and acute respiratory failure, Confalonieri and colleagues found no significant changes in pulmonary artery pressures and cardiac output by Doppler echo-
cardiography in 15 patients; 4 patients (21%) showed a significant reduction (> 15%) of cardiac output during NIV. Naughton and colleagues demonstrated another important hemodynamic benefit of CPAP in CHF. They studied 15 patients with CHF and 9 healthy controls, applying CPAP for 75 minutes and measuring inspiratory esophageal pressures and calculated left ventricular wall stress. Among CHF patients, CPAP seems to benefit patients with ACPE by decreasing left ventricular (LV) afterload and decreasing the inspiratory work of breathing without negatively affecting the cardiac index. Continuous positive airway pressure had no effect on healthy volunteers.

### Patient Selection

While NIV has reported benefits in various etiologies of ARF, it is important to avoid its use in patients with absolute contraindications. There are no uniform indications for NIV, as each study focuses on one type of ARF and often excludes patients with alternative diagnoses. **Table 4 on page 7** shows indications and initial ventilator settings described in the methods sections of selected clinical trials.

### Noninvasive Ventilation In The Prehospital Setting

Plaisance and colleagues performed a prehospital

### Table 3. Selected Published Guidelines For The Use Of Noninvasive Ventilation (continued on page 5)

<table>
<thead>
<tr>
<th>Organization</th>
<th>Topic</th>
<th>Type of Guideline</th>
<th>Recommendations</th>
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</thead>
<tbody>
<tr>
<td>American College of Emergency Physicians (ACEP) Clinical Policies Subcommittee (Writing Committee) on Acute Heart Failure Syndromes⁵</td>
<td>Clinical Policy: Critical Issues in the Evaluation and Management of Adult Patients Presenting to the Emergency Department with Acute Heart Failure Syndromes</td>
<td>Evidence-based</td>
<td>Use 5 to 10 cm H₂O CPAP by nasal or face mask as therapy for dyspneic patients with AHF syndrome without hypotension or the need for emergent intubation to improve heart rate, respiratory rate, and blood pressure and to reduce the need for intubation and possibly inhospital mortality (Grade B). Consider using bi-level NIV as an alternative to CPAP for dyspneic patients with AHF syndrome; however, data about the possible association between bi-level NIV and myocardial infarction remain unclear (Grade C).</td>
</tr>
<tr>
<td>British Thoracic Society⁶</td>
<td>Update of 2002 British Thoracic Society guideline for ARF in COPD</td>
<td>Evidence-based</td>
<td>NIV should be considered in all patients with an acute exacerbation of COPD in whom a respiratory acidosis (pH &lt; 7.35, PaCO₂ &gt; 6 kPa [45 mm Hg]) is present (Not graded).</td>
</tr>
<tr>
<td>Quality Standards Subcommittee of the American Academy of Neurology⁷</td>
<td>Practice Parameter Update: The Care of the Patient with Amyotrophic Lateral Sclerosis: Drug, Nutritional, and Respiratory Therapies</td>
<td>Evidence-based</td>
<td>NIV should be considered to treat respiratory insufficiency in ALS, both to lengthen survival (Level B) and to slow the decline of forced vital capacity (Level B). NIV may be considered to improve quality of life (Level C).</td>
</tr>
<tr>
<td>American College of Physicians – American Society of Internal Medicine (ACP-ASIM) and the American College of Chest Physicians (ACCP)¹¹</td>
<td>Management of Acute Exacerbations of Chronic Obstructive Pulmonary Disease: A Summary and Appraisal of Published Evidence</td>
<td>Evidence-based</td>
<td>Bi-level NIV is a beneficial support strategy that decreases the risk for invasive mechanical ventilation and possibly improves survival in selected hospitalized patients with respiratory failure (Not graded).</td>
</tr>
<tr>
<td>Global Initiative for Chronic Obstructive Lung Disease (GOLD)¹²</td>
<td>Global Strategy for the Diagnosis, Management, and Prevention of Chronic Obstructive Pulmonary Disease</td>
<td>Evidence-based</td>
<td>NIV improves respiratory acidosis (increases pH and decreases PaCO₂) and decreases respiratory rate, severity of breathlessness, and length of hospital stay in patients with acute exacerbations of COPD (Evidence A). Mortality—or its surrogate, intubation rate—is reduced by this intervention (Not graded).</td>
</tr>
<tr>
<td>American College of Critical Care Medicine¹³</td>
<td>Recommendations for end-of-life care in the intensive care unit: a consensus statement by the American Academy of Critical Care Medicine</td>
<td>Consensus</td>
<td>A patient who has specifically refused intubation but desires other aspects of intensive care with the goal of prolonging survival may choose NIV (Not graded). NIV may be used as a palliative technique to minimize dyspnea. When used for the latter indication, NIV should be stopped when it is no longer effective at relieving that symptom (Not graded).</td>
</tr>
</tbody>
</table>
study to determine whether the timing of NIV mattered.\textsuperscript{14} They enrolled patients with clinical signs of pulmonary edema and $\text{SpO}_2 < 90\%$ but excluded anyone with COPD. They compared immediate CPAP versus a 15-minute delay in administering CPAP and found that dyspnea scores were significantly improved in the early group compared with the delayed group at 15 minutes ($4 \pm 2$ vs $7 \pm 2$, $P = 0.003$). There was an impressive reduction in tracheal intubation between the groups, which was statistically significant (1 of 63 in the early CPAP group vs 8 of 61 in the late group, $P = 0.01$). In a systematic review, Simpson and Bendall found only 3 randomized trials that enrolled mostly patients with ACPE.\textsuperscript{15} Their results suggest that prehospital NIV may reduce both mortality and tracheal intubation by approximately 75\%. The number of patients remains small, but the potential benefits of the relatively unexplored area of prehospital NIV may be substantial. Overall, noninvasive ventilation shows promise in the prehospital setting, but more research is needed to determine its cost-effectiveness.

**Acute Exacerbation Of Chronic Obstructive Pulmonary Disease**

Ram and colleagues performed a Cochrane systematic review of NIV in acute exacerbations of COPD based on 14 clinical trials including 758 total

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**Table 3. Selected Published Guidelines For The Use Of Noninvasive Ventilation** (continued from page 4)

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<tr>
<td>Infectious Diseases Society of America/American Thoracic Society\textsuperscript{16}</td>
<td>Consensus Guidelines on the Management of Community-Acquired Pneumonia in Adults</td>
<td>Consensus</td>
<td>Patients with hypoxemia or respiratory distress should receive a cautious trial of NIV unless they require immediate intubation because of severe hypoxemia ($\text{PaO}_2/\text{FiO}_2$ ratio &lt; 150) and bilateral alveolar infiltrates (Moderate recommendation; level I evidence).</td>
</tr>
<tr>
<td>National Heart, Lung, and Blood Institute Expert Panel Report 3\textsuperscript{17}</td>
<td>Expert Panel Report 3: Guidelines for the Diagnosis and Management of Asthma</td>
<td>Evidence-based</td>
<td>Other adjunct therapies to avoid intubation include intravenous beta\textsubscript{2}-agonists, intravenous LTRAs, and NIV; however, insufficient data are available to make recommendations regarding these possible adjunct therapies (Evidence D).</td>
</tr>
<tr>
<td>European Society of Cardiology\textsuperscript{18}</td>
<td>European Society of Cardiology Guidelines for the Diagnosis and Treatment of Acute and Chronic Heart Failure</td>
<td>Evidence-based</td>
<td>NIV with PEEP should be considered as early as possible in every patient with acute cardiogenic pulmonary oedema and hypertensive AHF as it improves clinical parameters including respiratory distress. NIV with PEEP improves LV function by reducing LV afterload. NIV should be used with caution in cardiogenic shock and RV failure; however, the authors were unable to find evidence to support this cautious approach in RV failure or cardiogenic shock (Class I, Level C). Early application of NIV in patients with acute cardiogenic pulmonary oedema reduces both the need for intubation and short-term mortality (Class IIa, Level B). Intubation and mechanical ventilation should be restricted to patients in whom oxygen delivery is not adequate by oxygen mask or NIV and patients with increasing respiratory failure or exhaustion as assessed by hypercapnia (Class IIa, Level B).</td>
</tr>
<tr>
<td>Surviving sepsis campaign\textsuperscript{19}</td>
<td>International Guidelines for Management of Severe Sepsis and Septic Shock</td>
<td>Evidence-based</td>
<td>The guideline committee suggests that noninvasive mask ventilation only be considered in the minority of ALI/ARDS patients with mild-moderate hypoxemic respiratory failure (responsive to relatively low levels of pressure support and PEEP) with stable hemodynamics who can be made comfortable and easily arousable, are able to protect the airway, are able to spontaneously clear the airway of secretions, and are anticipated to recover rapidly from the precipitating insult. A low threshold for airway intubation should be maintained (Grade 2B).</td>
</tr>
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</table>

Abbreviations: AHF, acute heart failure; ALI, acute lung injury; ALS, amyotrophic lateral sclerosis; ARDS, acute respiratory distress syndrome; ARF, acute respiratory failure; COPD, chronic obstructive pulmonary disease; CPAP, continuous positive airway pressure; LTRAs, leukotriene receptor antagonists; LV, left ventricular; NIV, noninvasive ventilation; PEEP, positive end-expiratory pressure; RV, right ventricular.
patients. They found that it reduced mortality by approximately 50% (risk ratio [RR] 0.52; 95% CI, 0.35-0.76), decreased the need for intubation by approximately 60% (RR 0.41; 95% CI, 0.33-0.53), and reduced treatment failures by 52% (RR 0.48; 95% CI, 0.37-0.63). Additionally, patients on NIV showed a rapid improvement within the first hour in pH (weighted mean difference [WMD] 0.03; 95% CI, 0.02-0.04), PaCO₂ (WMD -0.40 kPa; 95% CI, -0.78 to -0.03), and respiratory rate (WMD -3.08 breaths per minute; 95% CI, -4.26 to -1.89). Complications associated with treatment and length of hospital stay were also reduced in the bi-level group.²⁰

The evidence shows impressive results in patients with an acute exacerbation of COPD. Its use should be strongly considered in these patients upon their arrival to the ED.

**Acute Exacerbation Of Asthma**

While NIV is considered an effective first-line treatment for acute exacerbation of COPD, the evidence supporting NIV for asthma is less convincing. This may be explained by the fundamental difference between asthma and COPD. The hallmark of emphysema is the destruction of pulmonary architecture that leads to premature collapse of the airways. This leads to inadequate ventilation and retention of CO₂. Inspiratory positive airway pressure may functionally stent these terminal airways and allow for more effective ventilation. On the other hand, asthma is manifested by inflammation, edema, and partial or complete obstruction of small airways. Noninvasive ventilation pressures, as they are currently used, may not be sufficient to overcome this degree of obstruction and associated resistance. This is reflected by the inconsistent pressure support settings that appear in the literature regarding NIV in acute asthma.

Ram and colleagues performed a Cochrane systematic review and meta-analysis. Starting with 11 clinical trials, they excluded 10, leaving only 1 randomized controlled trial.²¹ They concluded that the evidence supporting NIV for exacerbations of asthma was potentially promising but that a large randomized controlled trial was needed. In a pilot prospective randomized trial, Soroksky and colleagues enrolled ED patients whose forced expiratory volume in 1 second (FEV₁) was < 60% predicted after 30 minutes of standard treatment.²² They excluded patients with hemodynamic instability or who smoked for more than 10 years. Patients were randomized to either bi-level NIV or a sham NIV, which was set at 1 cm H₂O of positive airway pressure and had holes drilled in the tubing to eliminate positive pressure. Eighty percent of patients in the bi-level NIV group reached the predetermined primary end points (an increase of at least 50% in FEV₁, as compared to baseline) versus 20% of control patients (P < 0.004). Mean rise in FEV₁ was 53.5 ± 23.4% in the bi-level NIV group and 28.5 ± 22.6% in the control group (P = 0.006). Hospitalization was required for 3 of 17 patients (17.6%) in the bi-level NIV group as compared to 10 of 16 patients (62.5%) in the control group (P = 0.0134). Among the studies included in the Cochrane review was one by Meduri and colleagues. They performed an observational study of 17 patients with acute asthma and provided bi-level NIV using a face mask connected to a conventional ventilator.²³ While first applying the mask, initial settings included 10 cm H₂O IPAP and 0 cm H₂O EPAP. Once the mask was sealed to prevent air leaks, 3 to 5 cm H₂O EPAP was added on, and pressure support ventilation was increased to maintain a tidal volume (VT) of 7 mL/kg. All but 1 of the patients tolerated NIV, demonstrating improvements in PCO₂ and PaO₂/FiO₂. The other patients did not show improvement in the blood gas and were intubated.

A few other studies suggest that there may be a benefit of NIV in acute asthma. Subsequent to the Cochrane review, Soma and colleagues enrolled 44 patients with acute exacerbation of asthma who received nebulized medications and hydrocortisone. The patients were randomized into either high pressure (8 cm H₂O IPAP and 6 cm H₂O EPAP) or low-pressure (6 cm H₂O IPAP and 4 cm H₂O EPAP) bi-level NIV groups. The only improvements they noted were in wheezing and accessory muscle use scores.²⁴

Summarizing these findings, it is reasonable to consider NIV for patients with an acute exacerbation of asthma, but the effect will likely be modest, and the emergency clinician must remain prepared to intubate.

**Acute Cardiogenic Pulmonary Edema**

For years, it appeared that CPAP might be effective in reducing mortality in patients with ACPE. However, a large multicenter randomized controlled trial comparing CPAP, bi-level NIV, and standard oxygen therapy brings the mortality benefit into question. The Three Interventions in Cardiogenic Pulmonary Oedema (3CPO) trial enrolled 1069 patients, of which 367 received standard oxygen therapy, 346 received CPAP, and 356 received bi-level NIV.²⁵ There was no significant difference in 7-day mortality between the groups. There was also no difference in rates of tracheal intubation. The only significant improvements seen with either NIV group were modest reductions in dyspnea score, heart rate, acidosis, and hypercapnia. It also made no difference if the patient used CPAP or bi-level NIV. In a recent meta-analysis by Weng and colleagues, the authors reviewed 31 randomized controlled trials involving 2887 patients, including the 3CPO trial.²³ They concluded that CPAP versus standard therapy reduces mortality (RR 0.64; 95% CI, 0.44-0.92), and both CPAP and bi-level ventilation reduce the need
<table>
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<th>Diagnosis</th>
<th>Enrollment Criteria</th>
<th>NIV Settings</th>
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<tbody>
<tr>
<td>Gupta et al.</td>
<td>Asthma</td>
<td>RR &gt; 30, HR &gt; 100, SpO₂ &lt; 92% or PaO₂ &lt; 60 mm Hg</td>
<td>8 cm H₂O IPAP, 4 cm H₂O EPAP, titrated in 2 cm H₂O increments to a maximum of 20 cm H₂O IPAP and 10 cm H₂O EPAP</td>
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<tr>
<td>Soma et al.</td>
<td>Asthma</td>
<td>SpO₂ &gt; 90% on room air, EXCLUDED COPD, CHF, pneumonia, and pregnancy</td>
<td>Low pressure group: 6 cm H₂O IPAP and 4 cm H₂O EPAP, High pressure group: 8 cm H₂O IPAP and 6 cm H₂O EPAP</td>
</tr>
<tr>
<td>Delay et al.</td>
<td>Morbid obesity</td>
<td>BMI &gt; 40 kg/m², Elective surgery, EXCLUDED emergency procedures and other comorbidities</td>
<td>6 cm H₂O IPAP and 4 cm H₂O EPAP, after 20 seconds increased to 8-10 cm H₂O IPAP and 6 cm H₂O EPAP</td>
</tr>
<tr>
<td>Plaisance et al.</td>
<td>ACPE</td>
<td>Clinical ACPE, SpO₂ &lt; 90% on 15 L/min face mask, EXCLUDED COPD</td>
<td>Early CPAP at 7.5 cm H₂O, Late CPAP at 7.5 cm H₂O begun 15 minutes after early CPAP group</td>
</tr>
<tr>
<td>Moritz et al.</td>
<td>ACPE</td>
<td>Clinical ACPE, SpO₂ &lt; 90% on &gt; 5 L/min face mask, EXCLUDED COPD, pneumonia, and renal failure</td>
<td>CPAP at 10 cm H₂O delivered by Boussignac mask compared with bi-level NIV with EPAP of 5 cm H₂O and IPAP that was adjusted to maintain a VT of 8 to 10 mL/kg. The pressure support needed to reach this VT was approximately 12. Thus, IPAP was approximately 17 cm H₂O.</td>
</tr>
<tr>
<td>Ferrer et al.</td>
<td>AHRF</td>
<td>ICU patients, PaO₂ &lt; 60 mm Hg for &gt; 6 hours or SpO₂ &lt; 90% on &gt; 5 L/min face mask, EXCLUDED hypercapnia PaCO₂ &gt; 45 mm Hg</td>
<td>16 ± 3 cm H₂O IPAP (range 10-24) 7 ± 2 cm H₂O EPAP (range 4-12)</td>
</tr>
<tr>
<td>Conti et al.</td>
<td>Acute exacerbation of COPD</td>
<td>ICU consults of ED patients, pH &lt; 7.32, Bicarbonate &gt; 30 mEq/L, PaCO₂ &gt; 45 mm Hg, PaO₂ &lt; 45 mm Hg on room air</td>
<td>Bi-level NIV at IPAP of 21 ± 2 cm H₂O and EPAP of 5 cm H₂O (pressure support 16 ± 2 cm H₂O) compared with mechanical ventilation</td>
</tr>
<tr>
<td>Jolliet et al.</td>
<td>Severe CAP</td>
<td>ICU, Focal or multilobar pneumonia, RR ≥ 30/min, PaCO₂ ≥ 45 mm Hg, PaO₂/FiO₂ &lt; 300, BP systolic &lt; 90 mm Hg and diastolic &lt; 60 mm Hg, Vasopressor use ≥ 4 hours</td>
<td>Bi-level NIV at 20 cm H₂O IPAP and 5 cm H₂O EPAP (pressure support 15 cm H₂O)</td>
</tr>
<tr>
<td>Confalonieri et al.</td>
<td>CAP</td>
<td>RR &gt; 35/min, PaO₂ &gt; 68 mm Hg while on FiO₂ ≥ 0.4, PaO₂/FiO₂ &lt; 250 while on FiO₂ ≥ 0.5, PaCO₂ ≥ 50 mm Hg, BP systolic &lt; 90 mm Hg and diastolic &lt; 60 mm Hg, Vasopressor use ≥ 4 hours</td>
<td>Bi-level NIV with 19.7 ± 4.7 cm H₂O IPAP and 4.9 ± 1.7 cm H₂O EPAP (pressure support 14.8 ± 4.7 cm H₂O)</td>
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</table>

Abbreviations: ACPE, acute cardiogenic pulmonary edema; AHRF, acute hypoxemic respiratory failure; BMI, body mass index; BP, blood pressure; CAP, community-acquired pneumonia; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; CPAP, continuous positive airway pressure; ED, emergency department; EPAP, expiratory positive airway pressure; HR, heart rate; ICU, intensive care unit; NIV, noninvasive ventilation; RR, respiratory rate; VT, tidal volume.
Clinical Pathway: Management Of Patients With Respiratory Distress And Special Circumstances Using Noninvasive Ventilation

Does the patient have blunt thoracic trauma?
- **Yes**: Is the patient hypoxic despite 100% oxygen supplementation?
  - **Yes**: Use bi-level NIV, start at 10 cm H$_2$O IPAP and 6 cm H$_2$O *(Class II)*
  - **No**: NIV cannot be recommended at this time *(Class Indeterminate)*
- **No**: Does patient appear to have a neuromuscular cause for their respiratory failure?
  - **Yes**: Improving with oxygen?
    - **Yes**: Continue conventional therapy *(Class I)*
    - **No**: Use bi-level NIV, start at 10 cm H$_2$O IPAP and 5 cm H$_2$O EPAP *(Class II)*
  - **No**: Does patient appear to have a DNI order or is patient on palliative care?
    - **Yes**: Improving with oxygen and care appropriate for underlying disease process?
      - **Yes**: Continue conventional therapy *(Class I)*
      - **No**: Use NIV, depending on underlying disease process *(Class I for COPD and ACPE)*
    - **No**: Does patient appear to have ALI/ARDS or acute chest syndrome from sickle cell as a reason for their respiratory distress?
      - **Yes**: NIV cannot be recommended at this time *(Class Indeterminate)*
      - **No**: Continue conventional trauma resuscitation *(Class I)*

Please see Class of Evidence definitions on page 10

Abbreviations: ACPE, acute cardiogenic pulmonary edema; ALI, acute lung injury; ARDS, acute respiratory distress syndrome; COPD, chronic obstructive pulmonary disease; DNI, do not intubate; EPAP, expiratory positive airway pressure; IPAP, inspiratory positive airway pressure; NIV, noninvasive ventilation
Clinical Pathway: Management Of Patients With Respiratory Distress With Noninvasive Ventilation

Is patient obtunded, hypoxemic, or unable to protect airway? **YES**
- Prepare for rapid sequence tracheal intubation (Class I)
- Consider using NIV for pretreatment to intubation (Class I)

**NO**

Does patient appear to have an acute exacerbation of COPD or asthma? **YES**
- Improving with albuterol, ipratropium and methylprednisolone?
  **YES**
  - Continue conventional therapy (Class I)
  **NO**
  - Use bi-level NIV, start at 10 cm H₂O IPAP and 5 cm H₂O EPAP (COPD: Class I; Asthma: Class II)

**NO**

Does patient appear to have ACPE? **YES**
- Improving with oxygen, nitroglycerin and furosemide or other diuretic?
  **YES**
  - Continue conventional therapy (Class I)
  **NO**
  - Use CPAP, start at 10 cm H₂O (Class I)

**NO**

Does patient appear to have pneumonia with hypoxia? **YES**
- Improving with oxygen and IV antibiotics?
  **YES**
  - Continue conventional therapy (Class I)
  **NO**
  - Use bi-level NIV, start at 10 cm H₂O IPAP and 5 cm H₂O EPAP (Class I)

**NO**

Does patient appear to have another reason for their respiratory distress? **YES**
- Go to Clinical Pathway: Management Of Patients With Respiratory Distress And Special Circumstances Using Noninvasive Ventilation on page 8

Please see Class of Evidence definitions on page 10

Abbreviations: ACPE, acute cardiogenic pulmonary edema; CPAP, continuous positive airway pressure; COPD, chronic obstructive pulmonary disease; EPAP, expiratory positive airway pressure; IPAP, inspiratory positive airway pressure; IV, intravenous; NIV, noninvasive ventilation
Clinical Pathway: The Reevaluation Of Patients Placed On Noninvasive Ventilation

Is the patient deteriorating clinically (decreasing mental status, hypotension, hypoxemia rising PCO₂)?

YES ➔ Prepare for immediate tracheal intubation (Class I)

NO ➔

Is the patient complaining or becoming more anxious?

YES ➔ Consider sedation with remifentanil or dexmedetomidine (Class III)

NO ➔

Is the patient complaining about the mask or is there air leak?

YES ➔ Improving with change of mask?

YES ➔ Change NIV settings to maximize tidal volume, oxygenation, and PCO₂ (Class I)

NO ➔ Continue conventional therapy (Class I)

NO ➔ Admit to appropriate service and level of care (Class Indeterminate)

Does patient appear to be tolerating NIV and improving clinically?

YES ➔

NO ➔

Abbreviations: EPAP, expiratory positive airway pressure; IPAP, inspiratory positive airway pressure; NIV, noninvasive ventilation

Class Of Evidence Definitions

Each action in the clinical pathways section of EMCC receives a score based on the following definitions.

Class I
- Always acceptable, safe
- Definitely useful
- Proven in both efficacy and effectiveness

Level of Evidence:
- One or more large prospective studies are present (with rare exceptions)
- High-quality meta-analyses
- Study results consistently positive and compelling

Class II
- Safe, acceptable
- Probably useful
- Generally higher levels of evidence

Level of Evidence:
- Non-randomized or retrospective studies: historic, cohort, or case control studies
- Less robust RCTs
- Results consistently positive

Class III
- May be acceptable
- Possibly useful
- Considered optional or alternative treatments

Level of Evidence:
- Generally lower or intermediate levels of evidence
- Case series, animal studies, consensus panels
- Occasionally positive results

Indeterminate
- Continuing area of research
- No recommendations until further research

Level of Evidence:
- Evidence not available
- Higher studies in progress
- Results inconsistent, contradictory
- Results not compelling

for tracheal intubation.

Adverse effects of the hemodynamic changes associated with NIV have been reported. Hypotension is possible in hypovolemic patients, due the reduction in preload and cardiac output. A randomized controlled trial by Mehta and colleagues comparing CPAP to bi-level NIV in patients with ACPE suggested a concerning relationship between NIV and myocardial ischemia.34 This study was terminated early due to an excess of myocardial infarction (MI) in the bi-level NIV group. Newer and larger trials have refuted these findings, including the 3CPO trial. Bellone and colleagues specifically examined the occurrence of MI in patients presenting with ACPE and found no statistical difference in MI between the CPAP and bi-level NIV groups.35

Community Acquired Pneumonia

The evidence supporting NIV in CAP is also conflicting. Carron and colleagues studied 64 patients on ICU admission and placed them on bi-level NIV starting at 15 cm H₂O IPAP and 5 cm H₂O EPAP (thus providing 10 cm H₂O of pressure support).36 Noninvasive ventilation was successful in avoiding intubation in 28 (44%) patients and failed in 36 (56%) patients. In a logistic regression model, the change in PaO₂/FiO₂ and the oxygenation index (OI = mean airway pressure × FiO₂ × 100/PaO₂) was statistically associated with failure of NIV and need for intubation.36 In their guidelines on the management of CAP,16 the Infectious Diseases Society of America and the American Thoracic Society recommend cautious usage of NIV. They suggest that NIV be tried in patients with CAP and hypoxia and respiratory distress unless they require immediate intubation. They define need for immediate intubation as severe hypoxemia (PaO₂/FiO₂ < 150) or bilateral alveolar infiltrates.

Confalonieri and colleagues performed a case-control study of patients with *pneumocystis carinii* pneumonia (PCP) and ARF admitted to an infectious disease ICU.37 They applied bi-level NIV to 24 patients and matched them with controls that had been intubated prior to arriving at the ICU. They found that 67% of the bi-level NIV patients avoided tracheal intubation and had a shorter course in the ICU. While the authors tried to match the controls as closely as possible to the cases, there is still potential for bias, which might inflate the benefits of bi-level NIV. Yet, it is tempting to believe that a trial of bi-level NIV may prevent intubation in patients with PCP. Thus, a cautious trial of bi-level NIV in CAP is warranted, with tracheal intubation equipment on standby. Patients in respiratory distress should be tracheally intubated immediately if there is any doubt that they would be able to tolerate NIV.16

Pediatric Use Of Noninvasive Ventilation

The evidence base for NIV in pediatrics is limited but suggests that there may be benefit in ARF. Yanez and colleagues performed a randomized controlled trial in 50 patients in 2 pediatric ICUs.40 Patients predominantly had respiratory syncytial virus/bronchiolitis. Noninvasive ventilation was applied as bi-level NIV with IPAP ranging from 12 to 18 cm H₂O and EPAP ranging from 6 to 12 cm H₂O. The investigators found a significant reduction in tracheal intubation: 7 of 25 NIV patients versus 15 of 25 controls (RR 0.47; 95% CI, 0.23-0.9, P = 0.046).

Tools And Techniques: Practical Considerations For Noninvasive Ventilation

There are many ways to deliver NIV, and it is essential for the emergency clinician to communicate with the respiratory therapy department to know what is available in their facility. For a detailed overview of equipment options, we refer the reader to excellent reviews by Scala and Naldi38 and Schönhofer and Sorter-Leger.39 We will cover the key issues regarding the application of NIV in the ED. The goal of NIV in the ED patient is to stabilize their respiratory status. Using the techniques discussed in this article – mask sizing, delivery of sufficient but not excessive pressures, and management of patient anxiety by offering reassurance and possibly sedation – the patient’s ED course will be optimized.

Pressure Settings

For CPAP, it is reasonable to set the pressure at 10 cm H₂O for suspected ACPE. The pressure can be adjusted up or down depending on patient comfort. For bi-level NIV, start at 15 cm H₂O IPAP and 5 cm H₂O EPAP. The pressure support in this case is 10 cm H₂O (IPAP minus EPAP). These pressures may be titrated up or down depending on the combination of clinical effect as well as patient comfort. Based on the available literature, pressures should not exceed 25 cm H₂O at any point, regardless of the mode of NIV being used. In order to maintain the desired pressures, it is important to achieve a good seal with the NIV mask. Nasal masks are the simplest, but the patient must keep their mouth closed or the pressures will drop. The more common facial masks may achieve a better seal. Finally, the patient is key to the success of NIV. If the patient does not tolerate the mask or is anxious, the NIV trial may fail. The patient may also trigger the NIV machine prematurely and initiate an inappropriate breath. Newer NIV models have been developed with much more sophisticated circuitry that adjust the pressures and inspiratory and expiratory times when there is a leak. An experienced respiratory therapist is essential in successfully implementing NIV in the ED.
Mask Options And Sizing

Nasal Mask
Nasal NIV is often used for the patient who has a history of obstructive sleep apnea (typically CPAP mode) or COPD who needs nocturnal ventilation (typically bi-level NIV mode). With the nasal mask, the airway is depressurized and no longer a closed system when the patient opens his or her mouth. It causes less claustrophobia than the oronasal/facial or helmet masks. It also minimizes aspiration if vomiting occurs. In order to prevent pressure drop when the patient opens their mouth, nasal masks should only be used in ED patients who can reliably keep their mouth closed or cannot tolerate a face mask.

Oronasal (Face) Mask
Delivery of NIV via a facemask is the most common method used by emergency medical service personnel, in the ED, and in the ICU. One mask does not fit all when it comes to patients’ faces, and it is therefore important to stock a variety of sizes. A good fit will allow less air leak and improve patient comfort. Along with being attentive to the size of the patient’s face, the clinician should take note of both the edentulous patient who has no teeth to give the mouth firm structure and the bearded patient, both of whom are at risk for a poor mask fit and consequential air leaks. One small randomized controlled trial demonstrated that facemasks are significantly better tolerated by patients when compared to nasal masks for ARF from CHF. There was no difference in performance, however, with similar rates of intubation between these 2 groups. Another study found that the facemask was less tolerable despite allowing less air leakage than the nasal mask in patients with COPD exacerbation. (See Figures 1 and 2.)

Cephalic Mask
There are facemasks that cover the entire anterior surface of the face. The theoretical advantage is that it spreads out the pressure, reducing the nasal bridge breakdown of nasal or facial masks. Cuvelier and colleagues found no difference in 34 patients that they randomized to cephalic and oronasal masks. However, 1 patient from the cephalic group dropped out due to claustrophobia.

Helmet
The helmet is an uncommonly used interface for NIV in the ED, though studies outside the ED suggest that it may hold promise for patients who are intolerant of other masks. In a small study of post-abdominal surgery patients, the helmet was better tolerated with fewer complications (such as air leaks and pneumonia) compared to face mask. In a small case-control study in immunocompromised ICU patients with hypoxemic ARF, the helmet was shown to be of equal benefit in avoiding intubation, compared to the facemask, while leading to significantly fewer interruptions due to discomfort and complications, such as skin necrosis.

Boussignac Mask
The Boussignac mask is a promising new mask that provides CPAP up to 7.5 cm H2O without requiring a separate flow generator or ventilator. The apparatus operates with high flow oxygen and compares favorably with bi-level NIV in hypercapnic patients. This modality seems ideal for prehospital management of ARF in remote areas, but more research is needed before it can be recommended as an option for NIV in the ED. (See Figures 3 and 4.)
Clinical Course In The ED

Once the patient is placed on NIV, it is important to monitor the patient closely for clinical deterioration. Assume that NIV will fail, and prepare the necessary equipment for RSI. Consult with the respiratory therapist to ensure that the mask interface is comfortable for the patient and that the NIV modality – CPAP versus bi-level NIV – is set up as needed for the specific disease process.

Clinical parameters that one should follow include:

- Patient tolerance of NIV
- Increase in secretions
- Mental status change
- Synchronous breathing with the ventilator
- Air leaks
- Respiratory rate
- Tidal volume changes in relation to respiratory rate

Oxygen requirement in relation to the pulse oximetry
- Pulse oximetry
- Blood gases (see below)
- Tidal volumes and minute ventilation

Respiratory rate and work of breathing should decrease with intervention. However, respiratory rate is not the same as ventilation, so it is important to check an arterial blood gas for pH and PCO$_2$.

There is promising data that pH – but not PCO$_2$ – in venous blood gases correlates with arterial blood gases. This is exciting because it is more convenient to sample venous blood rather than performing an arterial puncture. A recent meta-analysis by Lim and Kelly suggests that in COPD patients, pH and bicarbonate show good correlation, but the correlation between venous and arterial PCO$_2$ is less reliable.47 There is not enough evidence to support the use of venous PCO$_2$ in patients with COPD, but pH may be useful. A rise in pH in a patient placed on NIV may well reflect improved ventilation and improvement of their hypercapnia.

Furthermore, Kelly and Klim studied a convenience sample of 46 patients on NIV who needed a blood gas.48 They measured transcutaneous CO$_2$ (PtCO$_2$) and compared it with the PCO$_2$ from the arterial blood gas (PaCO$_2$). They found very poor correlation between PtCO$_2$ and PaCO$_2$. Indeed, the transcutaneous measurement sometimes dramatically underestimated the true arterial CO$_2$. This is understandable as each modality of measuring the partial pressure of CO$_2$ has limitations. The gold standard is the arterial gas, where CO$_2$ is measured after diffusion has occurred at the alveolar level. The venous CO$_2$ may reflect hypercapnia, but this value may drop significantly upon passage through the lung. End-tidal CO$_2$ varies with dead space ventilation and may grossly underestimate the arterial CO$_2$. Transcutaneous CO$_2$ is dependent upon diffusion through the skin and may approach arterial levels when the skin is warm and well perfused. Thus, caution must be exercised when using PtCO$_2$ in patients on NIV as there is no support for PtCO$_2$ in this setting. Due to the poor agreement between PtCO$_2$ and PaCO$_2$, transcutaneous CO$_2$ monitoring in NIV cannot be recommended.

Deterioration

Parameters of failure in a patient on NIV include:

- Vomiting
- Persistent coughing
- Aspiration
- Progressive respiratory distress
- Respiratory arrest
- Loss of consciousness
- Respiratory rate rising greater than 35-40
- Persistent hypoxia despite supplemental oxygenation
- Hemodynamic instability or shock
Do-Not-Intubate And Palliative Care Patients
Nursing home or hospice patients often present to the ED in respiratory distress. While a clear do-not-intubate (DNI) order accompanying the patient makes the decision on whether to intubate less vexing, there is always the option of NIV. By definition, NIV is not invasive. It is important to explain to the patient and caregiver that this modality is an option. There is very little guidance on what the right course of action is in these cases. Levy and colleagues enrolled 114 patients on bi-level NIV who also happened to have DNI status. Noninvasive positive pressure ventilation was provided with 13.4 ± 0.3 cm H\(_2\)O IPAP and 5.0 ± 1 cm H\(_2\)O EPAP.\(^{51}\) There was a 43% survival to discharge. Patients most likely to survive were those with ACPE and COPD. Additional markers of survival were alert mental status and good, strong cough. Bulow and colleagues studied 38 patients who had a DNI order and were given NIV.\(^{52}\) The group with the highest survival was patients with COPD. They concluded that NIV is an option for patients with a DNI order and COPD, while other diagnoses may not fare as well.

Curtis and colleagues from the Society of Critical Care Medicine Palliative Noninvasive Positive Pressure Ventilation Task Force developed an approach for considering the use of NIV for those who wish to forego tracheal intubation.\(^{53}\) They provide a detailed approach to communicating with the patient...
and family as well as defining the goals of NIV. For example, an end-stage COPD patient may wish to forego tracheal intubation but agree to NIV to ease the discomfort of dyspnea.

**Neuromuscular Respiratory Failure**

Miller and colleagues from the Quality Standards Subcommittee of the American College of Neurology published an evidence-based update of guidelines on the management of amyotrophic lateral sclerosis (ALS). They recommend that NIV be considered to treat respiratory insufficiency in ALS, both to lengthen survival and to slow the rate of forced vital capacity decline. They give this recommendation a Level B based upon 1 Class I study and 3 Class III studies. Bourke and colleagues, who conducted the Class I study, randomized ALS patients to either bi-level NIV at a mean 15 cm H2O IPAP and mean 4 cm H2O EPAP compared with standard care. Non-invasive ventilation was associated with a survival benefit of 205 days among patients with ALS and good bulbar function but not in ALS patients with poor bulbar function.

Seneviratne and colleagues studied a retrospective cohort of 52 patients who presented with myasthenic crisis and were admitted to the ICU. Fourteen (58%) of the 24 patients initially given bi-level NIV with 12 cm H2O IPAP and mean 4 cm H2O EPAP compared with standard care. Non-invasive ventilation was associated with a survival benefit of 205 days among patients with ALS and good bulbar function but not in ALS patients with poor bulbar function.

In general, there is limited evidence of the efficacy of NIV in patients with neuromuscular respiratory failure. A cautious trial may be helpful in either ALS (with good bulbar function) or myasthenic crisis.

**Acute Chest Syndrome In Sickle Cell Patients**

In a pilot study, Fartoukh and colleagues randomized 67 patients with symptoms suggestive of acute chest syndrome to either standard oxygen therapy or bi-level NIV with 12 cm H2O IPAP and 5 cm H2O EPAP. There was no improvement in the primary outcome of hypoxemia at day 3. Neither was there a decrease in pain, transfusions, or length of hospital stay. At this time, NIV cannot be recommended for acute chest syndrome in sickle cell patients.

**Blunt Chest Trauma**

Hernandez and colleagues studied 50 patients admitted to the ICU within 48 hours of blunt thoracic trauma whose PaO2/FiO2 ratio remained below 200 for more than 8 hours on high flow oxygen. Most patients in this study developed ARF secondary to lung contusion. Bi-level NIV was applied at 10 to 12 cm H2O IPAP and 6 cm H2O EPAP, adjusting IPAP upwards by 2 cm H2O increments and EPAP at 1 cm H2O increments as needed to maintain oxygenation and inspiratory volumes. The intubation rate was higher in the oxygen-only group: 40% compared to 12% in the bi-level NIV group. For this reason, the trial was stopped early. The length of stay in hospital was also shorter in the bi-level NIV group. There was no change in survival rate. This study demonstrates the potential for bi-level NIV in blunt chest trauma. The mortality in each group was 1 patient (4%), which precludes an assessment of mortality benefit.

**Cystic Fibrosis**

Moran and colleagues addressed the use of NIV in cystic fibrosis in a Cochrane review. Their review included many small studies that examined outcomes such as clearance of secretions and sleep latency. At present, there is insufficient evidence to suggest that NIV would be helpful in cystic fibrosis patients who present to the ED, although NIV has been used with good effect in other settings.

**Sedation In The Anxious Patient**

Sedation of a patient in respiratory distress is a double-edged sword. The benefit is that the patient may become more cooperative. The risk is that they may decline due to the underlying respiratory insult and need for urgent intubation. A few studies have shown that some agents may benefit the anxious patient in whom an NIV trial is attempted. Rocco and colleagues studied 36 patients with hypoxemic ARF who were not tolerating NIV and who received remifentanil. Twenty-two (61%) patients were able to continue the NIV and 14 (29%) required intubation. Constantin and colleagues performed a similar study using remifentanil in patients who were not able to tolerate NIV. For patients still not sufficiently sedated, they added propofol. Twelve of 13 patients were able to avoid intubation.

The sedative dexmedetomidine has also shown promise. Akada and colleagues administered dexmedetomidine to 10 ICU patients who were agitated while receiving NIV for ARF. All patients were successfully weaned from NIV with no intubations and no clinically recognized episodes of aspiration.

**Noninvasive Ventilation For Preoxygenation During Tracheal Intubation**

Futier and colleagues randomized 66 morbidly obese patients undergoing preoxygenation for tracheal intubation. They compared 5 minutes of spontaneous breathing of 100% O2 with 2 types of NIV. The first intervention group received bi-level NIV with no more than 18 cm H2O IPAP and 6-8 cm H2O EPAP. The other NIV group received these settings plus a recruitment maneuver of 40 cm H2O for 40 seconds immediately following tracheal intubation. At the end of preoxygenation, PaO2 was higher in both NIV groups compared with conventional preoxygenation. Delay and colleagues randomized morbidly obese patients needing tracheal intubation...
Noninvasive ventilation is a valuable tool that should be considered for patients who present to the ED in respiratory failure. While there is strong evidence for improved outcomes using NIV in certain subtypes of ARF, one should avoid using NIV for patients in whom it is absolutely contraindicated. Potential problems will usually become apparent in the first 60 minutes of applying NIV. Any patient who deteriorates clinically must be rescued with a definitive airway intervention.

Case Conclusion

The respiratory therapist recommended CPAP at 10 cm H₂O. The oxygen saturation rose from the high 60s to the high 80s, and the patient was no longer diaphoretic. You placed a large bore peripheral IV, collected blood, and administered IV furosemide and nitroglycerin. You sent off a venous blood gas to follow the pH and PCO₂. These returned as pH = 7.20 and PCO₂ = 60. Based on the landmark studies by Kelly and colleagues - having kept in mind that they studied patients with acute COPD - you repeated the venous blood gas and noted that the pH had risen by 0.10 to 7.30, and the PCO₂ had dropped to 50. While the venous PCO₂ result may not have correlated well with arterial PCO₂, you felt confident that the pH was going in the right direction. The patient was no longer diaphoretic and even smiled for the first time. Chest radiograph confirmed acutely decompensated heart failure, and you felt satisfied that this patient would not need tracheal intubation. At least not for now...

References

Evidence-based medicine requires a critical appraisal of the literature based upon study methodology and number of subjects. Not all references are equally robust. The findings of a large, prospective, randomized, and blinded trial should carry more weight than a case report.

To help the reader judge the strength of each reference, pertinent information about the study, such as the type of study and the number of patients in the study, are included in bold type following the reference, where available. In addition, the most informative references cited in this paper, as determined by the authors, are noted by an asterisk (*) next to the number of the reference.


11. GOLD Science Committee Methodology and summary of new recommendations. Global strategy for diagnosis, management and prevention of COPD. 2010 update. 2010. (Evidence-based guideline; 624 references)


randomized trials, including 2881 patients)


51. Levy M, Tanios MA, Nelson D, et al. Outcomes of patients with do-not-intubate orders treated with noninvasive ven-
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1. Which of the following patients has an absolute contraindication to NIV?
   a. Patient with acute exacerbation of COPD with respiratory acidosis
   b. Dyspneic patient with productive cough and CAP
   c. Severe asthmatic patient with accessory muscle use
   d. Obtunded patient with excess respiratory secretions
   e. Patient with blunt chest trauma, pulmonary contusion, and hypoxemia

2. The most appropriate NIV modality for suspected ACPE is:
   a. CPAP
   b. Tracheal intubation with 5 cm H₂O of PEEP
   c. 100% nonrebreather mask
   d. 15 cm H₂O IPAP and 5 cm H₂O EPAP
   e. The Boussignac mask

3. The following clinical assessment may be dangerously inaccurate:
   a. Arterial PCO₂
   b. Venous pH
   c. PtCO₂
   d. PaO₂/FiO₂ ratio

4. Complications of NIV include all of the following EXCEPT:
   a. Barotrauma
   b. Gastric insufflation
   c. Severe hypoxemia
   d. Mucus plugging

CME Information

Date of Original Release: August 1, 2011. Date of most recent review: July 10, 2011. Termination date: August 1, 2014.

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Target Audience: This enduring material is designed for emergency medicine physicians, physician assistants, nurses, practitioners, and residents as well as intensivists and hospitalists.

Goals: Upon completion of this article, you should be able to: (1) demonstrate medical decision-making based on the strongest clinical evidence; (2) cost-effectively diagnose and treat the most critical ED presentations; and (3) describe the most common medicolegal pitfalls for each topic covered.

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