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Noninvasive Ventilation For Patients In Acute Respiratory Distress: An Update

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Abstract

Over the last 20 years, noninvasive ventilation (NIV) strategies have been used with increasing frequency. The ease of use of NIV makes it applicable to patients presenting in a variety of types of respiratory distress. In this review, the physiology of positive pressure ventilation is discussed, including indications, contraindications, and options for mask type and fit. Characteristics of patients who are most likely to benefit from NIV are reviewed, including those in respiratory distress from chronic obstructive pulmonary disease exacerbation and cardiogenic pulmonary edema. The literature for other respiratory pathologies where NIV may be used, such as in asthma exacerbation, pediatric patients, and community-acquired pneumonia, is also reviewed. Controversies and potential future applications of NIV are presented.

Case Presentations

Just as you are able to sit down for the first time in hours in the ED, a colleague walks by and says, "I don't know what's going on with your new patient, but she doesn't look good." You hurry to find a frail, elderly woman sitting upright, mouth agape. She is tachypneic, with a respiratory rate of 40 breaths/min, and is using accessory respiratory muscles. According to EMS, her pulse oximetry reading improved from 67% on 2-L nasal cannula to 80% on a 15-L nonrebreather mask. She has virtually no breath sounds on lung auscultation except for occasional faint wheezing. You initiate bilevel noninvasive ventilation (NIV), and inline continuous nebulizer treatments are started. The respiratory therapist suggests endotracheal intubation, and you suspect that extubation in the ICU will be difficult, further along the treatment course. As the respiratory therapist sets the bilevel NIV at a PIP 12 over PEEP 5, she asks you, "What parameters would make you decide to proceed with endotracheal intubation?"

Meanwhile, you are alerted to an EMS arrival in the resuscitation bay. They have brought an obese 60-something-year-old man, who was "found down." Initial evaluation was remarkable for somnolence with arousal to painful stimuli. He has been unable to provide his name or past medical history. His vital signs are remarkable for a respiratory rate of 10 breaths/min and hypoxia with a SpO_2 *in the mid-80s on room air. He has right lower lung basilar crackles. According to EMS, his hypoxia did not improve on a nonrebreather mask, so CPAP was initiated in the field. Since then, his* SpO_2 *has improved marginally to the high 80s, but he still arouses only to painful stimuli. During your initial assessment, the patient vomits into the NIV mask, aspirates, and his* SpO_2 *plummets when the face mask is removed. As you scramble to assemble RSI and intubation materials, you wonder if CPAP was contraindicated and if this airway catastrophe could have been prevented.*

Mulling over your stressful patient load, you walk to the bedside of a 9-year-old girl with a past medical history of cerebral palsy. Although she is only minimally interactive, she is accompanied by her attentive parents who are deeply involved with her medical care. Her mother looks worried and explains that her daughter "isn't breathing right" and that she feels warm. The father mentions a history of a worsening cough. On chart review, you note that her restrictive lung disease from underlying cerebral palsy is worsening, and that she now requires BPAP at night. On examination, you see a mentally and developmentally delayed girl with subcostal retractions, tachycardia to 125 beats/min, tachypnea to 35 breaths/min, and an oral temperature of 38.3°C (101°F), but she is maintaining an oxygen saturation of 97% on room air. A chest x-ray confirms a right upper lobar pneumonia. The patient shows increased work of breathing, and you wonder if NIV would help.

Introduction

Acute respiratory failure is an emergency that requires a management strategy tailored to the individual patient and to the resources available. Endotracheal intubation is definitive airway management, but it can have complications. In addition, rapid sequence intubation (RSI) requires a degree of preparation and time that might not be available in the acutely distressed patient. For example, important equipment needs assembly, often the clinical environment is not optimal (such as with refractory hypoxia or abnormal anatomy that makes RSI riskier), or the patient has an underlying condition that could lead to further complication as a result of paralysis (such as in acidosis). Ultimately, with RSI there is a level of risk to the patient, both during the initial procedure of induction, sedation, laryngoscopy, and tube delivery, as well as post procedure, with ventilator-associated risks such as pulmonary barotrauma or ventilator-associated pneumonia.

In consideration of risks associated with definitive airway management, noninvasive strategies that include continuous positive airway pressure (CPAP) and bilevel positive airway pressure (BPAP) are viable management options. These techniques provide a "fast-on" intervention that provides more respiratory support than nasal cannula or a conventional face mask. Unlike endotracheal intubation, NIV is not definitive airway management, and the patient must be closely monitored for signs of clinical deterioration. Nonetheless, NIV can improve the patient's condition sufficiently to either reverse the underlying acute illness or, alternatively, it may serve to safely delay intubation until proper setup is available.[1] In the case of patients who have a "do not intubate" (DNI) directive, NIV may also allow for temporary life-sustaining support while a potentially reversible process is addressed.[2]

NIV was introduced for management of acute respiratory failure in the 1940s, but became a mainstay of respiratory management only in the last 20 years. A multicenter database review over a 15-year study period from 1997 to 2011 showed that first-line NIV use increased from 29% to 42%, and the success rate improved from 69% to 84%.[3] Success was defined as not requiring use of mechanical ventilation and increased patient survival.

A comprehensive understanding of the physiologic benefits of NIV can lead to efficient and clinically appropriate management decisions. As there was an excellent review article by Torres and Radeos published in a 2011 issue of *EM Critical Care*,[4] this review is designed to provide an update of the literature since then, and to offer evolving perspectives on the increasing utilization of NIV in the setting of acute respiratory distress.

Critical Appraisal Of The Literature

Searches were conducted through PubMed and OVID Medline® for literature from 2010 to 2016. Keywords included *noninvasive ventilation*, with and without the qualifying inclusion of the term *acute respiratory failure*, to limit the resources to acute conditions. The search was restricted to studies available in the English language. The references from the articles identified were then searched for additional references, retrieving more than 700 articles. Priority was given to articles addressing commonly occurring emergent medical conditions, with additional special attention given to topics falling under the category of emerging areas of research.

Types Of Respiratory Failure

Acute or acute-on-chronic respiratory failure can be conceptually divided into 2 major management categories: hypoxic respiratory failure and hypercarbic respiratory failure. Hypoxic respiratory failure is a disease state of inadequate oxygenation, while hypercarbic respiratory failure is due to inadequate ventilation. Management approaches are outlined in **Table 1**. Clinically, there is often overlap between these 2 types of respiratory failure, such as is seen in chronic obstructive pulmonary disease (COPD) exacerbation.

Clinical Application Of Noninvasive Ventilation

Positive Pressure Ventilation

NIV relies on the creation of positive pressure. Understanding the physiologic pathways involved is crucial to clinical decision-making. Positive pressure ventilation (PPV) applies a consistently positive airway pressure that results in increased laminar flow.

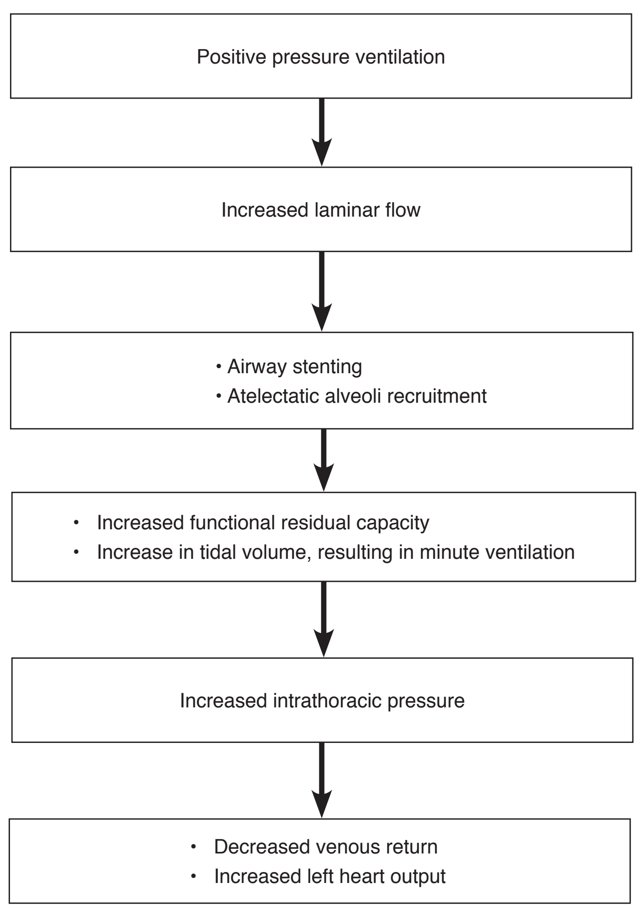
Table 1. Types Of Respiratory Failure And Their Management Approaches

Type of Respiratory Failure	Examples	Management Approach
Hypoxic (inadequate oxygenation)	• Pneumonia • Congestive heart failure • Interstitial respiratory disease	• Increase fraction of inspired oxygen • Increase mean airway pressure • Increase peak end-expiratory pressure
Hypercarbic (inadequate ventilation)	• Chronic obstructive pulmonary disease	• Increase respiratory rate • Increase tidal volume

(See Figure 1.) This leads to airway stenting and elimination of dead space through recruitment of atelectatic alveoli, resulting in increased functional residual capacity and an increase in tidal volumes due to improved lung filling, directly increasing minute ventilation.[5] However, the beneficial effects of PPV are not due simply to pulmonary recruitment. In patients with pulmonary edema due to decompensated heart failure, the impact of PPV may be due more to its hemodynamic effects. PPV increases intrathoracic pressure, and this increase, relative to extrathoracic compartments, can both decrease venous return and increase left heart output. In other words, PPV can decrease both preload and afterload.

In the clinical setting, such as in patients with congestive heart failure, the adjustment of preload, afterload, and redistribution of pulmonary blood flow from alveolar recruitment is what provides symptomatic relief and decrease of pulmonary edema.[6] Finally, PPV decreases the work of breathing by eliminating the patient's need to overcome airway resistance.

Figure 1. Physiologic Pathway Of Positive Pressure Ventilation



Types Of Noninvasive Ventilation

There are 2 main types of NIV—CPAP and BPAP—and understanding the differences is critical for respiratory management of patients. CPAP provides constant delivery of the same fixed positive pressure during both inspiration and expiration, and the resulting alveolar recruitment and hemodynamic effects contribute primarily to increased oxygenation. In comparison, BPAP delivers 2 levels of positive pressure: a lower level during expiration and a higher level during inspiration. The inspiratory positive airway pressure (IPAP) and expiratory positive airway pressure (EPAP) can be adjusted independently. Adjustments to the difference between these 2 pressures, a value referred to as *pressure support* (or the *delta pressure*), allows for greater or lesser tidal volumes. Assuming a fixed respiratory rate, the greater the difference between EPAP and IPAP, the greater the minute ventilation, which leads to decreased partial pressure of carbon dioxide, arterial ($PaCO_2$).

An emergency clinician must understand how to use NIV in the clinical setting. This requires an understanding of NIV settings and equipment, the indications and contraindications for use, and how to appropriately select patients based on their pathology.

Noninvasive Ventilation Settings And Types

Modes

Multiple systematic reviews and randomized controlled trials have demonstrated no significant difference in clinical outcomes between ventilator modes, and most conclude that the decision regarding modes is institution- and resource-dependent.[7,8]

Pressure Settings

Consider starting CPAP at a pressure of 10 cm H_2O. BPAP can be started at an IPAP of 10 cm H_2O and EPAP of 5 cm H_2O to create pressure support of 5 cm H_2O. The pressure settings should subsequently be titrated based on clinical response, including the patient's respiratory rate, oxygen saturation, and device tolerance. Based on available clinical evidence, IPAP > 20 cm H_2O is poorly tolerated, may cause gastric insufflation, and is therefore not recommended.[9]

Mask Types

There are several types of masks used for NIV, with each having advantages and disadvantages. Choice of mask should be based on patient factors and indications for NIV. **(See Table 2.)**

Disposable CPAP Systems

Introduction of the Boussignac CPAP system allows for increased adoption of NIV into the prehospital setting. **(See Figure 2, page 5.)** It utilizes the direct flow of a simple oxygen source (such as a portable or wall-mounted cylinder) to generate up to 10 cm H_2O CPAP. This is done by creating peak end-expiratory pressure (PEEP) through air turbulence generated by accelerated oxygen flow through the center of the chamber. Several studies have demonstrated similar

Table 2. Ventilation Mask Types And Uses

Mask Type	Advantages	Disadvantages	Considerations
Nasal mask and nasal pillow	• Fewer complaints of claustrophobia and facial discomfort • Enhanced clearance of oral airway to prevent aspiration events • Improved oral hygiene during hospitalization	• Requires the patient's mouth to remain closed for appropriate pressurization • According to Navalesi et al, nasal masks may be less efficacious than full-face mask in lowering of $PaCO_2$ ($P < .01$)[10]	• Useful in the treatment of obstructive sleep apnea and COPD • Patient compliance to keep the mouth closed can be difficult in settings of acute dyspnea or respiratory distress
Oronasal mask	• Most familiar to providers • Girault et al showed less NIV failure as compared to nasal mask group[11] ($P < .0001$)	• Patient may have fit issues if there is facial hair, obesity, abnormal nasal contours, or edentulousness • Long-term complications: nasal congestion, mouth dryness, pressure sores, discomfort, agitation	• Recommended first-line strategy in managing respiratory failure
Cephalic mask	• Even distribution of pressure around entire face leads to minimized air leaks and skin injury[12]	• Chacur et al in an RCT did not find significant difference in treatment efficacy when compared with oronasal mask[13]	• Consider using if the patient is not tolerating traditional oronasal masks, especially for patients with do-not-resuscitate directives[14]
Helmet	• No specific advantages when compared to other modalities	• Uncommonly encountered in the emergency department	• Conflicting studies and results on efficacy and ability to improve $PaCO_2$ as compared to other NIV modalities[15-17]

Abbreviations: COPD, chronic obstructive pulmonary disease; $PaCO_2$, partial pressure of carbon dioxide, arterial; NIV, noninvasive ventilation; RCT, randomized controlled trial.

efficacy of Boussignac CPAP compared to traditional CPAP and BPAP in both the prehospital and emergency department (ED) settings.[18-27]

Indications And Contraindications To Noninvasive Ventilation

Unfortunately, no clear consensus exists on the indications for NIV, likely due to heterogeneous etiologies of undifferentiated patients with respiratory distress. Therefore, it is easier to consider it potentially useful in any patient with respiratory distress unless there are contraindications. **(See Table 3.)** Generally, patients who are at increased risk for aspiration or patients who cannot fit the NIV masks are poor candidates for NIV. In addition, patients should have sufficient mental and physical capacity to protect their airway before NIV is applied.[28]

Patient Selection Based Upon Underlying Pathology

Undifferentiated Dyspnea In The Prehospital Setting

A 2014 systematic review and meta-analysis by Mal et al included 7 randomized controlled trials comprised of 632 patients. The review demonstrated a significant reduction of in-hospital mortality and need for invasive ventilation when NIV was applied in the prehospital setting.[29] (In-hospital mortality: relative risk [RR] 0.58; 95% confidence interval [CI], 0.35 to 0.95; number needed to treat [NNT], 18. Need for invasive ventilation: RR, 0.37; 95% CI, 0.24 to 0.58; NNT, 8.) They concluded that, in the distressed patient with undifferentiated dyspnea who appears likely to require intubation and lacks any contraindications, a trial of NIV was reasonable in the prehospital setting.

Figure 2. The Boussignac CPAP System

Abbreviation: CPAP, continuous positive airway pressure.
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Chronic Obstructive Pulmonary Disease Exacerbation

Positive pressure support has been emphatically shown to improve morbidity and mortality in COPD exacerbations. NIV increases tidal volumes leading to increased minute ventilation and decreased respiratory rate, thus leading to a decreased $PaCO_2$ and increased partial pressure of oxygen, arterial (PaO_2).[30] In a 2004 Cochrane review, a meta-analysis of 14 studies showed improvement with NIV through improved symptoms and pulmonary function.[31] This review, as well as other studies, also showed decreased rates of intubations and complications (such as barotrauma or neurological events), shorter hospital stays, and decreased hospital costs.[32,33] Further study has shown that patients with severe COPD exacerbation, acidotic patients, and elderly patients with APACHE II (Acute Physiology and Chronic Health Evaluation II) scores < 29 and Glasgow Coma Scale (GCS) scores > 9, are specific subpopulations that benefit the most from NIV.[34,35] For the online tool from MD+CALC to calculate the APACHE II score, go to www.mdcalc.com/apache-ii-score/. The GCS Score calculator is available at: www.mdcalc.com/glasgow-coma-scale-score-gcs/.

Asthma Exacerbation

Although the pathophysiology of asthma differs from that of COPD, NIV remains a component in most asthma treatment pathways. Most of the associated studies are small, but they do show improvement in pulmonary function.[36-42] A Cochrane review

Table 3. Absolute And Relative Contraindications To Noninvasive Ventilation

Absolute Contraindications
- Need for immediate endotracheal intubation
- Excess respiratory secretions
- High risk of vomiting and aspiration
- Past facial surgery precluding proper mask fit

Relative Contraindications
- Decreased level of consciousness
- Hemodynamic instability
- Severe hypoxia and/or hypercapnia, PaO_2/FiO_2 ratio of < 200 mm Hg
- $PaCO_2$ > 60 mm Hg
- Poor patient cooperation
- Lack of trained or experienced staff

Abbreviations: FiO_2, fraction of inspired oxygen; PaO_2, partial pressure of oxygen, arterial; $PaCO_2$, partial pressure of carbon dioxide, arterial.

published in 2012 that included 5 separate trials on the study of NIV in status asthmaticus was inconclusive, largely due to small sample size and flaws in methodological design.[43] A separate study performed by Nanchal et al used the Healthcare Cost and Utilization Project National Inpatient Sample database to examine whether NIV contributed to a change in patient outcomes.[44] Despite increasing use of NIV and decreasing rates of invasive mechanical ventilation, hospital stay and adjusted mortality rates in asthma exacerbations remained unchanged.

Cardiogenic Pulmonary Edema

There is high-quality evidence that NIV decreases the need for intubation and improves mortality in acute cardiogenic pulmonary edema, although it is not universally accepted as part of the treatment course. Both CPAP and BPAP are used in this patient population, although CPAP more robustly shows clinical improvement as demonstrated in the 2010 meta-analysis by Weng et al. This meta-analysis included 31 randomized controlled trials and concluded that CPAP reduced mortality and rates of intubation in cardiogenic pulmonary edema.[45] An updated Cochrane review from 2013 by Vital et al involving 32 studies concluded that NIV in cardiogenic pulmonary edema significantly reduced hospital mortality and intubation rates.[46-49]

Community-Acquired Pneumonia

While antibiotic therapy is the main treatment for patients with community-acquired pneumonia (CAP), other supportive measures, including NIV, have been studied for use in severe cases. Studies have shown NIV significantly reduced the need for intubation and duration of intensive care unit (ICU) stay, but it did not improve mortality.[50] A 2012 Cochrane review of 3 randomized controlled trials concluded that NIV in CAP significantly reduced the rate of intubation, reduced the risk of death in the ICU, and shortened ICU stays when compared to usual care, but NIV did not significantly reduce the rate of hospital mortality or hospital length of stay. Unfortunately, the level of evidence, overall, was found to be weak.[51] Severe illness and lack of improvement in clinical symptoms after 1 hour of NIV use were the strongest predictors of NIV failure.[52]

Interstitial Lung Disease

The use of NIV in patients with interstitial lung disease has not been well established. Patients who progress to respiratory failure requiring mechanical ventilation have a poor prognosis and a mortality rate > 80%.[53] Overall mortality rates remain high, and no benefit to NIV in severe interstitial lung disease has been demonstrated, but in patients with lower disease severity, NIV can be considered as a means to avoid or delay intubation.[54-57]

Submersion Injury

Submersion injury pathophysiology involves defective alveolar surfactant in alveoli that progresses to alveolar collapse and V/Q (ventilation/perfusion) mismatch.[58-61] Treatment depends upon symptomatology, but should emphasize respiratory support.[62-64] Symptomatic patients who have stable mental status can be considered for NIV therapy, as the positive pressure may help to address alveolar collapse and pulmonary edema. However, early intubation is advocated in patients who are severely symptomatic.[65-67]

Pediatric Patients

Although NIV is well established in the adult population, the data from the pediatric population are sparse and studies often lack large patient enrollment and have issues with design methodology. Additionally, the neonatal indications for NIV are very different from pediatric indications.[68-70]

In a literature review by Vitaliti et al, the authors conclude that successful NIV application in pediatric patients is based upon careful patient selection, application of the therapy before patient deterioration, good mask fit, and close monitoring.[71]

Clinical Course In The Emergency Department

Once it is decided that NIV is a viable option, the emergency clinician needs to optimize the clinical course and monitor for signs of clinical deterioration and complications. This may require frequent examinations, laboratory tests, and reassessments. A 3-year observational study in France identified 3 factors as early predictors of NIV failure: [72]

1. Respiratory failure that is not acute-on-chronic (eg, pneumonia)
2. Acidosis, with pH < 7.3
3. Severe hypoxemia, assessed after 1 hour on NIV

Interestingly, this study did not find altered mental status at the time of admission or various ventilator parameters as early indicators for NIV failure.[72] A similar correlation between pneumonia, low serum albumin level, and failure of NIV was also made in a 3-year observational prospective study of 176 patients.[73] It is also thought that patients with high intrinsic PEEP, commonly due to air trapping from advanced disease, are likely to fail NIV. This is primarily due to an inability to create enough peak inspiratory pressure to overcome the patient's intrinsic PEEP.[74] The overarching rule for these patients is to ensure frequent $PaCO_2$ monitoring and early intervention if there is respiratory failure.

Chronic Obstructive Pulmonary Disease

Optimizing treatment of COPD is largely determined by minimizing intrinsic PEEP, work of breathing, and metabolic demand, and by appropriate goal fraction of inspired oxygen (FiO_2). Savi et al were the first to examine trending arterial blood gas samples to assess for the most appropriate FiO_2. Blood gas samples in 17 ICU patients on NIV and at FiO_2 level = 1.0 and FiO_2 level < 0.5 were compared. Despite increased PaO_2 levels in the FiO_2 = 1.0 group, there were no changes in the $PaCO_2$ or pulmonary dynamics between groups.[75]

Asthma

Although there is a lack of evidence regarding use of NIV in an acute asthma exacerbation, anecdotally, there appears to be positive influence on clinical course, perhaps through decreased work of breathing. A trial of NIV prior to intubation is likely valuable in the management algorithm for those patients, barring absolute contraindications. If the patient does not experience improvement in respiratory status within 1 to 2 hours of use, NIV should be abandoned.

Use of inline nebulizer treatments is also commonly employed while the patient with asthma is receiving NIV. Galindo-Filho et al utilized a gamma camera to determine radio-aerosol pulmonary deposition and extrapolate information on pulmonary function and pulmonary clearance.[76] Although there was no improvement in particle deposition or pulmonary clearance in the NIV group, this same group showed overall improvement in pulmonary function testing.

Cardiogenic Pulmonary Edema

Application of NIV is associated with improved symptoms and oxygen saturation in patients with acute cardiogenic pulmonary edema. An observational study by Carvalho et al recorded statistically significant improvements in respiratory rate, pulse, arterial pH, $PaCO_2$, and peripheral O_2 saturation within 1 hour of NIV application, suggesting that early application can dramatically improve respiratory status.[77]

Community-Acquired Pneumonia

Although the data show that NIV may have beneficial application in CAP for medical management, it has not been clearly shown to benefit patients with CAP outside of concomitant COPD. In select patients, NIV can be trialed to improve oxygenation and support ventilation. A randomized controlled trial by Consentini et al demonstrated that patients receiving CPAP reached goal oxygenation more quickly and consistently than those receiving standard therapy.[78]

Clinical Deterioration On Noninvasive Ventilation

Patients requiring NIV in the ED setting are typically critically ill and should be closely observed for decompensation. **(See Table 4.)** The emergency clinician should be prepared to troubleshoot the administration of NIV or escalate to endotracheal intubation.

Complications Of Noninvasive Ventilation

As with any modality, there are complications associated with NIV that the emergency clinician must anticipate and be prepared to manage.

Risk Of Aspiration

The use of NIV results in an increased risk for aspiration and gastric insufflation, and the risk is increased if there is fluctuating mental status. Therefore, the clinician must ensure the patient is capable of protecting his airway. Inability to protect the airway is a contraindication for NIV.

Barotrauma

PPV can cause barotrauma leading to pneumothorax from increased airway pressures, although this occurs less frequently with NIV compared to traditional invasive mechanical ventilation. It can be mitigated by closely observing titration of the patient's pressure support requirements.[79] NIV can also lead to hypotension resulting from increased intrathoracic pressures that cause decrease in cardiac preload.

Cardiac Ischemia

There is concern in the setting of cardiogenic pulmonary edema that NIV may lead to increased risk for cardiac ischemia. Two studies have shown that NIV helped improve oxygenation and respiratory

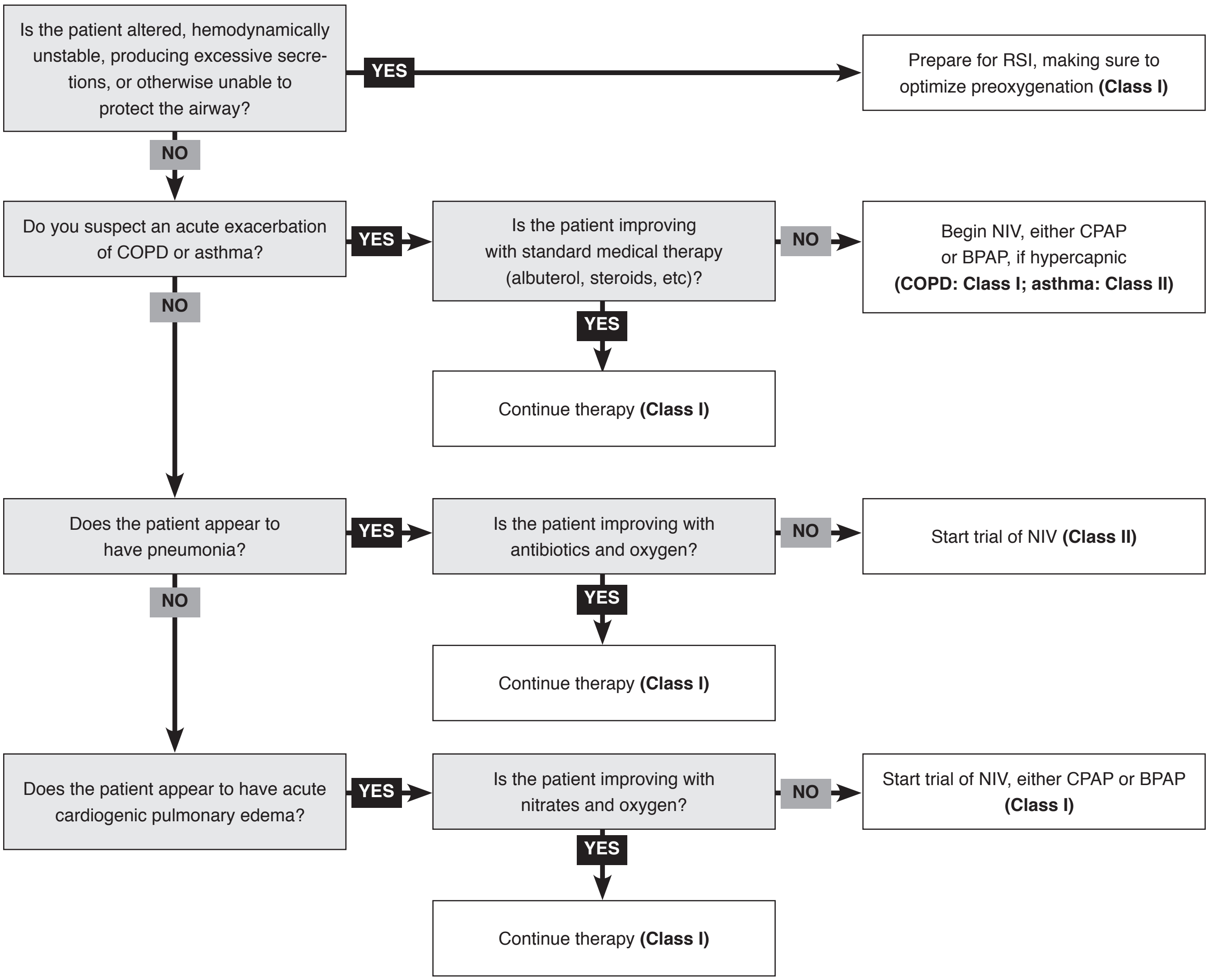
Table 4. Signs Of Noninvasive Ventilation Failure

- Vomiting with or without aspiration
- Persistent coughing
- Asynchrony of patient breathing with the NIV machine
- Declining level of consciousness
- Persistent hypoxia despite supplemental oxygen and increasing PEEP
- Hemodynamic instability
- Worsening pH, increasing $PaCO_2$, or decreasing PaO_2
- Worsening PaO_2/FiO_2 ratio

Abbreviations: FiO_2, fraction of inspired oxygen; NIV, noninvasive ventilation; PaO_2, partial pressure of oxygen, arterial; $PaCO_2$, partial pressure of carbon dioxide, arterial; PEEP, positive end-expiratory pressure.

Reprinted from: Jose Dionisio Torres, Jr.; Michael S. Radeos. Noninvasive Ventilation: Update on Uses for the Critically Ill Patient. *EM Critical Care.* 2011;1(2):1-20. Used with permission.

Clinical Pathway For Managing Patients In Respiratory Distress



Abbreviations: BPAP, bilevel positive airway pressure; COPD, chronic obstructive pulmonary disease; CPAP, continuous positive airway pressure; NIV, noninvasive ventilation; RSI, rapid sequence intubation.

Class Of Evidence Definitions

Each action in the clinical pathways section of *Emergency Medicine Practice* 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

Level of Evidence:
- Generally higher levels of evidence
- Nonrandomized or retrospective studies: historic, cohort, or case control studies
- Less robust randomized controlled trials
- 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

This clinical pathway is intended to supplement, rather than substitute for, professional judgment and may be changed depending upon a patient's individual needs. Failure to comply with this pathway does not represent a breach of the standard of care.

support status faster than medication or conventional oxygen administration alone, but there was an increased rate of acute myocardial ischemia in patients enrolled in the PPV group.[47,49] Additionally, 2 meta-analyses showed that CPAP had more efficacy over BPAP in patients with cardiac ischemia.[8,80] Conversely, a 2010 meta-analysis showed decreased mortality from cardiogenic pulmonary edema, with no impact on cardiac ischemia, when patients received NIV.[45] A small randomized trial performed by Liesching et al showed more-rapid patient improvement on BPAP compared to CPAP with no increase in the rate of cardiac ischemia.[81] Further investigation is needed to determine the validity of this association and to determine which is the preferred modality, BPAP versus CPAP. Based on the best available evidence, for this patient population, we recommend judicious use of PPV of either modality, with particularly close clinical monitoring, throughout the course of treatment, for any developing cardiac ischemia.

Special Circumstances

Acute Lung Injury/Acute Respiratory Distress Syndrome

Despite advances in management, a diagnosis of acute lung injury or acute respiratory distress syndrome portends a high mortality rate. Studies comparing mortality and rates of ventilator-acquired pneumonia associated with NIV versus invasive ventilation have produced mixed findings. A meta-analysis of NIV use in acute lung injury by Agarwal et al advised cautious use of NIV in this high-risk population, as their investigation identified a 50% NIV failure rate, with a 48% intubation rate and 35% mortality.[82] A more recent trial by Zhan et al found that the NIV group had a lower rate of intubation compared to controls.[83] These authors concluded that use of NIV may be safe in selected patients who are observed carefully.

Do-Not-Intubate Orders And Palliative Care

With the increasing elderly patient population, the ED is caring for more palliative care patients and patients with DNI orders. NIV can be used as respiratory support, especially for patients approaching the end of life who may have a reversible process. Additionally, NIV can also briefly extend time for those in the ED who are waiting for loved ones to arrive.[84]

Providing comfort is also an important part of palliative care. Nava et al examined the use of NIV in end-of-life treatment. They compared comfort level and need for opioids in patients on NIV versus traditional oxygen through reservoir masks. They showed that patients on NIV required less opioids and, overall, suffered less from dyspnea.[2] Patients who have NIV initiated in the ED or during hospitalization show prolonged and improved quality of life, although mortality remains high due to underlying disease processes.[85-88]

Neuromuscular Respiratory Failure

Respiratory failure is a serious and life-threatening complication for a heterogeneous group of patients with neuromuscular disorders. NIV is most useful in patients who require temporary or intermittent (eg, nighttime) support. A prospective cohort study by Servera et al in 17 patients with neuromuscular respiratory failure found that NIV with mechanical cough assistance successfully averted death and intubation in 79.2% of acute episodes.[89] In patients requiring long-term use of intermittent mechanical ventilation, NIV may be useful for preventing or delaying progression of chronic respiratory failure. Bourke et al found that, in patients without severe bulbar dysfunction, NIV improved survival and quality of life.[90]

Blunt Chest Trauma

Rib fractures, pulmonary contusions, pneumothorax, hemothorax, and flail chest are the injuries most commonly associated with blunt chest trauma.[91] Use of NIV in patients with these injuries was first described in 1980 by Uretzky et al in a case study of severe acute respiratory distress syndrome following a blast injury.[92] A 2013 systematic review and meta-analysis conducted by Chiumello et al reviewing NIV in patients with blunt chest trauma found that patients treated with NIV versus standard care (defined as oxygen administration or invasive mechanical ventilation) had decreased mortality. Patients treated with NIV also had significantly lower intubation rates, infection rates, and shorter ICU stays.[93]

Cystic Fibrosis

NIV plays a role in the management of cystic fibrosis by helping to clear secretions and in managing exacerbations. Two Cochrane reviews of current literature on positive expiratory pressure physiotherapy showed that NIV can decrease rates of pulmonary exacerbations in patients with cystic fibrosis.[94,95] Studies have also shown that NIV can be a bridge to lung transplantation.[96] During treatment of an acute exacerbation, NIV can be helpful to assist with airway obstruction from mucus plugging, but definitive data are relatively sparse.

Controversies And Cutting Edge

Sedation For Noninvasive Ventilation

Sedation for NIV has not been traditionally used, since altered mental status is a contraindication. However, patients in extremis often cannot tolerate NIV due to discomfort from the mask apparatus, claustrophobia, and other sources of anxiety. There are recent case reports, observational trials, and randomized controlled studies reviewing the utility and safety of sedative medications in improving tolerance of NIV. The most commonly described drug classes include opioids (remifentanil), benzodiazepines (midazolam), and the alpha-2 adrenergic agonist, dexmedetomidine.

Contantin et al evaluated the use of remifentanil as sedation for discomfort/anxiety-related NIV failure. They found continuous infusion of remifentanil was associated with improved NIV tolerance, decreased tachypnea, increased PaO_2/FiO_2, and decreased $PaCO_2$.[97] Rocco et al reported improved tolerance of NIV and decreased failure rates when using a remifentanil-based sedation regimen in 36 patients initially intolerant of NIV.[98] Both studies concluded that remifentanil for light sedation of a patient in acute respiratory failure may improve the likelihood of successful treatment, without deterioration.

A 2012 study by Huang et al compared dexmedetomidine to midazolam in patients who were poorly tolerating NIV for acute pulmonary edema. The study found that continuous infusion of dexmedetomidine resulted in a greater reduction in percentage rates of NIV failure than midazolam and a prolonged mean time to endotracheal intubation.[99] Conversely, a 2014 randomized controlled trial of early-initiated dexmedetomidine demonstrated no improvement in NIV tolerance over placebo. However, it is notable that this study population was started on sedation regardless of initial tolerance.[100]

Noninvasive Ventilation In Procedural Sedation

Many procedures performed in the ED are painful and require sedation to perform, and patients may develop airway obstruction due to relaxation of the upper airway structures during the sedation.[101] A case report in 2010 by Remick et al described successful use of NIV in a morbidly obese patient with a history of obstructive sleep apnea who underwent sedation for electrical cardioversion of new-onset

Risk Management Pitfalls For Noninvasive Ventilation

(Continued on page 11)

1. **"I wanted to start NIV in the ED, but I did not know the exact etiology of the patient's respiratory distress."**
   Often, a patient will present to the ED in undifferentiated respiratory distress, but can still benefit from a trial of NIV. However, NIV should not be attempted if the patient meets contraindications, which are detailed in **Table 2 (page 4).** An emergency clinician should remain vigilant and be ready for mechanical ventilation if the patient does not improve while on NIV.

2. **"NIV was started via oronasal mask on the patient with respiratory distress, but I had to stop because he complained of nasal dryness and discomfort."**
   There are many options for mask type and fit. As long as the patient remains stable, other modalities should be tried.

3. **"EMS brought a patient to the ED on NIV instead of intubating him. I think they were just novice and were too scared to intubate."**
   It is reasonable to trial NIV in patients in the prehospital setting, and it can reduce in-hospital mortality and the need for invasive ventilation. However, if a patient continues to decompensate, the care team should be prepared for intubation.

4. **"I did not consider that the patient could get a pneumothorax while on NIV."**
   PPV can increase the risk of barotrauma, which can lead to pneumothorax from the increased airway pressure. While rates of these events are lower than in mechanical ventilation, it can still happen. This should be a part of the differential diagnosis in an acutely unstable patient on NIV who initially appeared to have been improving clinically.

5. **"The patient with the do-not-resuscitate order appeared short of breath, so I treated his air hunger with morphine. Now the family is upset with me because the patient passed away before they could get to the ED. I did not want the patient to suffer any longer."**
   The physician can consider starting NIV while the family is en route to the ED, and it may be a safer treatment for air hunger than opioids. This can provide extra time for family to arrive, which may be part of the patient's end-of-life goals and the process of dying with dignity. However, NIV should, ideally, only be applied with consent after approval from the patient or their duly appointed medical designee.

atrial fibrillation.[102] Strayer and Caputo published a study of 11 patients with a mean body mass index of 25.8 who were undergoing procedural sedation in the ED in whom NIV was successfully used.[103] The authors noted this was only a feasibility study, and a larger study would be necessary.

Disposition

Disposition of a patient on NIV ranges from discharge home, admission for observation, admission to the medical/surgical floor, or admission to the critical care setting. Unfortunately, many hospitals have policies that preclude the patient on NIV from any disposition except for a step-down unit or ICU equivalent. While an ICU setting is ideal for a patient who develops worsening respiratory status requiring intubation, patients on NIV often improve quite rapidly.[104,105] For stable patients or those with a do-not-resuscitate/do-not-intubate order, application of NIV and admission to the general ward may be appropriate. This requires a conversation with the patient (or his or her surrogate), decision-makers, and the medical team that will assume care.

Summary

NIV is a potentially lifesaving and stabilizing means of ventilatory support that has entered the mainstream of daily emergency practice. The ease of application and, at times, the almost immediate relief of respiratory instability can significantly improve the clinical outcome of many patients. Nonetheless, the emergency clinician must remain vigilant, especially with fragile patients, and be prepared to intubate for mechanical ventilation when necessary. Developing expertise in NIV requires understanding of the pathophysiology of PPV and mastering the mechanics of ventilation and oxygenation. This includes knowledge of indications and contraindi-

Risk Management Pitfalls For Noninvasive Ventilation

(Continued from page 10)

6. **"I thought the patient was comfortable and starting to fall asleep. I didn't think that it was possible to be hypercapnic and go into respiratory failure while on NIV."**
NIV is not an advanced airway, and any patient placed on this intervention must be closely monitored for deterioration. Signs of NIV failure include declining level of consciousness, which may be caused by worsening $PaCO_2$ levels. Serial examinations, blood gas testing, and vital signs are critical for monitoring these patients. Remember that tachypnea and hyperventilation are not the same thing. Patients with rapid, shallow breathing can still accumulate dangerous levels of $PaCO_2$, and NIV does not guarantee a minimum minute ventilation.

7. **"My patient will not stop coughing and her breathing is asynchronous with the NIV machine. I'll give her opioids to make her more comfortable so that I do not have to intubate her, and she can benefit from NIV."**
Care must be taken with patients receiving NIV. If they cannot tolerate it or show signs of NIV failure, then they will require intubation. Coughing and asynchrony are signs of ineffective NIV that may lead to failure. While light sedation can be given while on NIV, it must be done with extreme caution to avoid oversedation that may necessitate emergency intubation.

8. **"I know the patient I'm admitting for cellulitis will require ICU admission because he requires BPAP at night."**
This is not necessarily true. You should consider discussing with the inpatient care team the optimal disposition for the patient. Not all patients who need NIV will require ICU-level care.

9. **"The pediatric patient who presented to the ED in respiratory distress has never been on NIV, so I did not want to start a new therapy in the ED."**
Although data are lacking, there is reasonable physiologic rationale to support the use of NIV in the ICU in the pediatric patient population, even without previous use. It may prevent intubation, which is important. It is reasonable to try NIV in conjunction with the pediatric ICU team's directed care.

10. **"The ICU team was upset when I told them that I placed the patient with the asthma exacerbation on NIV. They stated that the exact correlation between NIV use in asthma and physiological improvement is unknown."**
While it is true that asthma and COPD are fundamentally different in pathophysiology, they are both obstructive processes and NIV can still be helpful, assuming it does not prevent the physician from intubation if the patient deteriorates. It can also be helpful for preoxygenation prior to intubation for the already-hypoxic patient.

cations of NIV, various mask and fit options, and appropriate patient selection. Most critically, the emergency clinician must recognize symptoms of clinical deterioration in a patient on NIV. The growing literature base and enthusiasm to explore additional applications of NIV in other disease states and clinical settings will likely lead to increased adoption of this intervention.

Case Conclusions

Your first patient was in hypoxic respiratory failure, as evidenced by her low oxygen saturation. Underlying COPD exacerbation was presumed, based upon her physical examination. Your patient had already attempted to physiologically compensate for her respiratory failure with an increased respiratory rate. With BPAP, her tidal volume and mean airway pressure increased. The constant baseline airway pressure led to increased oxygenation. Finally, the mechanical support decreased her work of breathing and prevented full respiratory collapse. You checked on her several times over the first 10 minutes on BPAP, and noted that she was no longer using accessory muscles to breathe, her respiratory rate had decreased to 18, her SpO_2 had risen to 96%, and you were able to wean her FiO_2. Each time you approached her, she opened her eyes wider, smiled, and nodded her head. You rechecked a VBG and were delighted to see that her pH had risen from 7.2 to 7.3 and her $PaCO_2$ had come down from 79 to 61. There was still work to do, but she was headed in the right direction.

With your second patient, after noting copious vomiting, you decided that it was wise to intubate this still-undifferentiated patient. A physical examination and laboratory tests revealed that the patient was acutely intoxicated. The patient was admitted to the critical care team.

The pediatric patient was admitted to the pediatric ICU due to her need for noninvasive ventilator support. As you continued to follow her case over the next several days, you were pleased to learn that, despite a critical case of pneumonia, she never required intubation. Her admitting team was able to balance her need for ventilatory support with an aggressive pulmonary regimen. She was slowly weaned off continuous BPAP. Her altered mental status made this patient higher risk for initiation of NIV, but it was not an absolute contraindication.

Time- And Cost-Effective Strategies

- Immediately implement NIV for patients who arrive to the ED in respiratory distress (particularly from acute exacerbations of COPD), after ensuring the absence of absolute contraindications. **(See Table 1, page 3.)** This may prevent the need for mechanical intubation.
  Risk Management Caveat: Be sure to closely monitor your patient on NIV with persistent respiratory distress. If there is, at any time, presence of an absolute contraindication, relative contraindication, or signs of NIV failure **(see Table 3, page 5)**, then your patient will require intubation.
- Discuss NIV respiratory management with patients who have DNI orders and/or are considering palliative care. End-of-life discussions are very important in the ED. It is possible that you will encounter patients who are found to have terminal disease presenting with respiratory distress. Patients and their families will appreciate knowing that there are options for ventilatory management that are not invasive and can be easily be applied, removed, or otherwise modified for their situation.
- Use NIV judiciously in patients presenting to the ED with respiratory distress. Anecdotally, early use of NIV within the ED can enable a patient who was critically ill to improve rapidly and avoid an admission to the ICU. This is important to recognize as a potential time- and cost-saving strategy, especially in times of ED overcrowding.

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 is included in bold type following the reference, where available. 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.

1. Weingart SD, Trueger NS, Wong N, et al. Delayed sequence intubation: a prospective observational study. *Ann Emerg Med.* 2015;65(4):349-355. **(Multicenter prospective observational; 62 patients)**
2. Nava S, Ferrer M, Esquinas A, et al. Palliative use of non-invasive ventilation in end-of-life patients with solid tumours: a randomised feasibility trial. *Lancet Oncol.* 2013;14(3):219-227. **(Randomized; 200 patients)**
3. Schnell D, Timsit JF, Darmon M, et al. Noninvasive mechanical ventilation in acute respiratory failure: trends in use and outcomes. *Intensive Care Med.* 2014;40(4):582-591. **(Multicenter review; 1232 patients)**
4. Torres JD RM. Non-invasive ventilation: update for uses in the critically ill patient. *EM Critical Care.* 2011;1. **(Review)**
5. Carlson JN, Wang HE. Noninvasive airway management. In: Cline DM, Ma OJ, Cydulka RK, et al. *Tintinalli's Emergency Medicine: A Comprehensive Study Guide, 7th ed.* New York, NY: The McGraw-Hill Companies; 2012. **(Textbook)**
6. Bersten AD, Holt AW, Vedig AE, et al. Treatment of severe cardiogenic pulmonary edema with continuous positive airway pressure delivered by face mask. *N Engl J Med.* 1991;325(26):1825-1830. **(Prospective; 39 patients)**
7. Masip J, Roque M, Sanchez B, et al. Noninvasive ventilation in acute cardiogenic pulmonary edema: systematic review

and meta-analysis. *JAMA.* 2005;294(24):3124-3130. **(Meta-analysis; 15 studies, 843 patients)**
8. Ho KM, Wong K. A comparison of continuous and bi-level positive airway pressure non-invasive ventilation in patients with acute cardiogenic pulmonary oedema: a meta-analysis. *Crit Care.* 2006;10(2):R49. **(Meta-analysis; 7 studies, 290 patients)**
9.* Siegel TA. Mechanical ventilation and noninvasive ventilatory support. In: Marx JA, Hockberger RS, Walls RM, et al, eds. *Rosen's Emergency Medicine, 8th ed.* Philadelphia, PA: Elsevier Saunders; 2014. **(Textbook)**
10. Navalesi P, Fanfulla F, Frigerio P, et al. Physiologic evaluation of noninvasive mechanical ventilation delivered with three types of masks in patients with chronic hypercapnic respiratory failure. *Crit Care Med.* 2000;28(6):1785-1790. **(Randomized; 26 patients)**
11. Girault C, Briel A, Benichou J, et al. Interface strategy during noninvasive positive pressure ventilation for hypercapnic acute respiratory failure. *Crit Care Med.* 2009;37(1):124-131. **(Prospective randomized controlled; 90 patients)**
12. Silva RM, Timenetsky KT, Neves RC, et al. Adaptation to different noninvasive ventilation masks in critically ill patients. *J Bras Pneumol.* 2013;39(4):469-475. **(Observational; 245 patients)**
13. Chacur FH, Vilella Felipe LM, Fernandes CG, et al. The total face mask is more comfortable than the oronasal mask in noninvasive ventilation but is not associated with improved outcome. *Respiration.* 2011;82(5):426-430. **(Prospective randomized; 60 patients)**
14. Lemyze M, Mallat J, Nigeon O, et al. Rescue therapy by switching to total face mask after failure of face mask-delivered noninvasive ventilation in do-not-intubate patients in acute respiratory failure. *Crit Care Med.* 2013;41(2):481-488. **(Prospective observational; 74 patients)**
15. Ozlem CG, Ali A, Fatma U, et al. Comparison of helmet and facial mask during noninvasive ventilation in patients with acute exacerbation of chronic obstructive pulmonary disease: a randomized controlled study. *Turk J Med Sci.* 2015;45(3):600-606. **(Randomized; 50 patients)**
16. Yang Y, Sun L, Liu N, et al. Effects of noninvasive positive-pressure ventilation with different interfaces in patients with hypoxemia after surgery for Stanford type A aortic dissection. *Med Sci Monit.* 2015;21:2294-2304. **(Randomized; 40 patients)**
17. Antonaglia V, Ferluga M, Molino R, et al. Comparison of noninvasive ventilation by sequential use of mask and helmet versus mask in acute exacerbation of chronic obstructive pulmonary disease: a preliminary study. *Respiration.* 2011;82(2):148-154. **(Prospective randomized; 53 patients)**
18. Wong DT, Tam AD, Van Zundert TC. The usage of the Boussignac continuous positive airway pressure system in acute respiratory failure. *Minerva Anestesiol.* 2013;79(5):564-570. **(Review; 19 references)**
19. Templier F, Dolveck F, Baer M, et al. 'Boussignac' continuous positive airway pressure system: practical use in a prehospital medical care unit. *Eur J Emerg Med.* 2003;10(2):87-93. **(Prospective descriptive; 57 patients)**
20. Fyntanidou B, Amaniti E, Fortounis K, et al. Prehospital use of Boussignac continuous positive airway pressure system in acute cardiogenic pulmonary edema [abstract]. *Eur J Anaesthesiol.* 2009;26:178. **(Abstract)**
21. Freitas P, Limpo B, Sa N, et al. Prehospital Boussignac continuous positive airway pressure: one year experience. *Resuscitation.* 2010;81:S56. **(Abstract)**
22. Dieperink W, Weelink EE, van der Horst IC, et al. Treatment of presumed acute cardiogenic pulmonary oedema in an ambulance system by nurses using Boussignac continuous positive airway pressure. *Emerg Med J.* 2009;26(2):141-144. **(Prospective interventional; 32 patients)**
23. Moritz F, Benichou J, Vanheste M, et al. Boussignac continuous positive airway pressure device in the emergency care of acute cardiogenic pulmonary oedema: a randomized pilot study. *Eur J Emerg Med.* 2003;10(3):204-208. **(Randomized; 30 patients)**
24. Dieperink W, Jaarsma T, van der Horst IC, et al. Boussignac continuous positive airway pressure for the management of acute cardiogenic pulmonary edema: prospective study with a retrospective control group. *BMC Cardiovasc Disord.* 2007;7:40. **(Prospective interventional; 66 patients)**
25. Moritz F, Brousse B, Gellee B, et al. Continuous positive airway pressure versus bilevel noninvasive ventilation in acute cardiogenic pulmonary edema: a randomized multicenter trial. *Ann Emerg Med.* 2007;50(6):666-675. **(Randomized; 120 patients)**
26. Nouira S, Boukef R, Bouida W, et al. Non-invasive pressure support ventilation and CPAP in cardiogenic pulmonary edema: a multicenter randomized study in the emergency department. *Intensive Care Med.* 2011;37(2):249-256. **(Randomized; 200 patients)**
27. Leman P, Greene S, Whelan K, et al. Simple lightweight disposable continuous positive airways pressure mask to effectively treat acute pulmonary oedema: randomized controlled trial. *Emerg Med Australas.* 2005;17(3):224-230. **(Randomized controlled; 39 patients)**
28. Weingart SD, Levitan RM. Preoxygenation and prevention of desaturation during emergency airway management. *Ann Emerg Med.* 2012;59(3):165-175. **(Review; 97 references)**
29. Mal S, McLeod S, Iansavichene A, et al. Effect of out-of-hospital noninvasive positive-pressure support ventilation in adult patients with severe respiratory distress: a systematic review and meta-analysis. *Ann Emerg Med.* 2014;63(5):600-607. **(Meta-analysis; 7 studies, 632 patients)**
30. Diaz O, Iglesia R, Ferrer M, et al. Effects of noninvasive ventilation on pulmonary gas exchange and hemodynamics during acute hypercapnic exacerbations of chronic obstructive pulmonary disease. *Am J Respir Crit Care Med.* 1997;156(6):1840-1845. **(Prospective; 10 patients)**
31.* Ram FS, Picot J, Lightowler J, et al. Non-invasive positive pressure ventilation for treatment of respiratory failure due to exacerbations of chronic obstructive pulmonary disease. *Cochrane Database Syst Rev.* 2004(1):CD004104. **(Cochrane review; 14 studies)**
32. Brochard L, Mancebo J, Wysocki M, et al. Noninvasive ventilation for acute exacerbations of chronic obstructive pulmonary disease. *N Engl J Med.* 1995;333(13):817-822. **(Prospective randomized; 85 patients)**
33. Lindenauer PK, Stefan MS, Shieh MS, et al. Outcomes associated with invasive and noninvasive ventilation among patients hospitalized with exacerbations of chronic obstructive pulmonary disease. *JAMA Intern Med.* 2014;174(12):1982-1993. **(Retrospective cohort; 25,628 patients)**
34. Keenan SP, Sinuff T, Cook DJ, et al. Which patients with acute exacerbation of chronic obstructive pulmonary disease benefit from noninvasive positive-pressure ventilation? A systematic review of the literature. *Ann Intern Med.* 2003;138(11):861-870. **(Systematic review; 15 studies)**
35. Keenan SP, Powers CE, McCormack DG. Noninvasive positive-pressure ventilation in patients with milder chronic obstructive pulmonary disease exacerbations: a randomized controlled trial. *Respir Care.* 2005;50(5):610-616. **(Randomized controlled; 25 patients)**
36. Soroksky A, Klinowski E, Ilgyev E, et al. Noninvasive positive pressure ventilation in acute asthmatic attack. *Eur Respir Rev.* 2010;19(115):39-45. **(Review; 58 references)**
37. Gupta D, Nath A, Agarwal R, et al. A prospective randomized controlled trial on the efficacy of noninvasive ventilation in severe acute asthma. *Respir Care.* 2010;55(5):536-543. **(Prospective randomized controlled; 53 patients)**
38. Meduri GU, Cook TR, Turner RE, et al. Noninvasive positive pressure ventilation in status asthmaticus. *Chest.*

1996;110(3):767-774. **(Prospective; 17 patients)**

39. Soroksky A, Stav D, Shpirer I. A pilot prospective, randomized, placebo-controlled trial of bilevel positive airway pressure in acute asthmatic attack. *Chest.* 2003;123(4):1018-1025. **(Randomized; 30 patients)**
40. Patrick W, Webster K, Ludwig L, et al. Noninvasive positive-pressure ventilation in acute respiratory distress without prior chronic respiratory failure. *Am J Respir Crit Care Med.* 1996;153(3):1005-1011. **(Prospective; 11 patients)**
41. Fernandez MM, Villagra A, Blanch L, et al. Non-invasive mechanical ventilation in status asthmaticus. *Intensive Care Med.* 2001;27(3):486-492. **(Retrospective observational; 58 patients)**
42. Shivaram U, Miro AM, Cash ME, et al. Cardiopulmonary responses to continuous positive airway pressure in acute asthma. *J Crit Care.* 1993;8(2):87-92. **(Retrospective; 58 patients)**
43. Lim WJ, Mohammed Akram R, Carson KV, et al. Non-invasive positive pressure ventilation for treatment of respiratory failure due to severe acute exacerbations of asthma. *Cochrane Database Syst Rev.* 2012;12:CD004360. **(Cochrane review; 6 studies, 206 patients)**
44.* Nanchal R, Kumar G, Majumdar T, et al. Utilization of mechanical ventilation for asthma exacerbations: analysis of a national database. *Respir Care.* 2014;59(5):644-653. **(Database review)**
45. Weng CL, Zhao YT, Liu QH, et al. Meta-analysis: noninvasive ventilation in acute cardiogenic pulmonary edema. *Ann Intern Med.* 2010;152(9):590-600. **(Meta-analysis)**
46.* Vital FM, Ladeira MT, Atallah AN. Non-invasive positive pressure ventilation (CPAP or bilevel NPPV) for cardiogenic pulmonary oedema. *Cochrane Database Syst Rev.* 2013;5:CD005351. **(Cochrane review; 32 studies, 2916 patients)**
47. Mehta S, Jay GD, Woolard RH, et al. Randomized, prospective trial of bilevel versus continuous positive airway pressure in acute pulmonary edema. *Crit Care Med.* 1997;25(4):620-628. **(Prospective randomized; 27 patients)**
48. Rusterholtz T, Kempf J, Berton C, et al. Noninvasive pressure support ventilation (NIPSV) with face mask in patients with acute cardiogenic pulmonary edema (ACPE). *Intensive Care Med.* 1999;25(1):21-28. **(Prospective; 26 patients)**
49. Sharon A, Shpirer I, Kaluski E, et al. High-dose intravenous isosorbide-dinitrate is safer and better than Bi-PAP ventilation combined with conventional treatment for severe pulmonary edema. *J Am Coll Cardiol.* 2000;36(3):832-837. **(Prospective randomized; 40 patients)**
50. Confalonieri M, Potena A, Carbone G, et al. Acute respiratory failure in patients with severe community-acquired pneumonia. A prospective randomized evaluation of noninvasive ventilation. *Am J Respir Crit Care Med.* 1999;160(5 Pt 1):1585-1591. **(Prospective randomized; 56 patients)**
51.* Zhang Y, Fang C, Dong BR, et al. Oxygen therapy for pneumonia in adults. *Cochrane Database Syst Rev.* 2012;3:CD006607. **(Cochrane review; 3 studies, 151 patients)**
52. Nicolini A, Ferraioli G, Ferrari-Bravo M, et al. Early non-invasive ventilation treatment for respiratory failure due to severe community-acquired pneumonia. *Clin Respir J.* 2016;10(1):98-103. **(Prospective; 127 patients)**
53. Raghu G, Collard HR, Egan JJ, et al. An official ATS/ERS/JRS/ALAT statement: idiopathic pulmonary fibrosis: evidence-based guidelines for diagnosis and management. *Am J Respir Crit Care Med.* 2011;183(6):788-824. **(Practice guideline)**
54. Vianello A, Arcaro G, Battistella L, et al. Noninvasive ventilation in the event of acute respiratory failure in patients with idiopathic pulmonary fibrosis. *J Crit Care.* 2014;29(4):562-567. **(Retrospective chart review; 18 patients)**
55. Gungor G, Tatar D, Salturk C, et al. Why do patients with interstitial lung diseases fail in the ICU? A 2-center cohort study. *Respir Care.* 2013;58(3):525-531. **(Observational cohort; 120 patients)**
56. Yokoyama T, Kondoh Y, Taniguchi H, et al. Noninvasive ventilation in acute exacerbation of idiopathic pulmonary fibrosis. *Intern Med.* 2010;49(15):1509-1514. **(Retrospective chart review; 11 patients)**
57. Mollica C, Paone G, Conti V, et al. Mechanical ventilation in patients with end-stage idiopathic pulmonary fibrosis. *Respiration*. 2010;79(3):209-215. **(Retrospective chart review; 34 patients)**
58. Modell JH, Graves SA, Ketover A. Clinical course of 91 consecutive near-drowning victims. *Chest.* 1976;70(2):231-238. **(Retrospective case review; 91 patients)**
59. Pendergast DR, Lundgren CE. The underwater environment: cardiopulmonary, thermal, and energetic demands. *J Appl Physiol* (1985). 2009;106(1):276-283. **(Review)**
60. Orlowski JP, Szpilman D. Drowning. Rescue, resuscitation, and reanimation. *Pediatr Clin North Am.* 2001;48(3):627-646. **(Review)**
61. Epstein M. Renal effects of head-out water immersion in humans: a 15-year update. *Physiol Rev.* 1992;72(3):563-621. **(Review)**
62. Szpilman D. Near-drowning and drowning classification: a proposal to stratify mortality based on the analysis of 1,831 cases. *Chest.* 1997;112(3):660-665. **(Review; 2304 patients)**
63. Noonan L, Howrey R, Ginsburg CM. Freshwater submersion injuries in children: a retrospective review of seventy-five hospitalized patients. *Pediatrics.* 1996;98(3 Pt 1):368-371. **(Retrospective chart review; 75 patients)**
64. van Berkel M, Bierens JJ, Lie RL, et al. Pulmonary oedema, pneumonia and mortality in submersion victims; a retrospective study in 125 patients. *Intensive Care Med.* 1996;22(2):101-107. **(Retrospective; 125 patients)**
65. Layon AJ, Modell JH. Drowning: update 2009. *Anesthesiology.* 2009;110(6):1390-1401. **(Review)**
66. Nelson SW, McCorvey SC. Submersion and drowning injuries. 2015. Available at: http://www.ahcmedia.com/articles/135278-submersion-and-drowning-injuries. Accessed September 7, 2016. **(Online review)**
67. Szpilman D, Bierens JJ, Handley AJ, et al. Drowning. *N Engl J Med.* 2012;366(22):2102-2110. **(Review)**
68. Mayordomo-Colunga J, Medina A, Rey C, et al. Predictive factors of non invasive ventilation failure in critically ill children: a prospective epidemiological study. *Intensive Care Med.* 2009;35(3):527-536. **(Prospective observational; 116 patients)**
69. Dohna-Schwake C, Stehling F, Tschiedel E, et al. Non-invasive ventilation on a pediatric intensive care unit: feasibility, efficacy, and predictors of success. *Pediatr Pulmonol.* 2011;46(11):1114-1120. **(Retrospective chart review; 74 patients)**
70. Abadesso C, Nunes P, Silvestre C, et al. Non-invasive ventilation in acute respiratory failure in children. *Pediatr Rep.* 2012;4(2):e16. **(Prospective observational; 151 patients)**
71. Vitaliti G, Wenzel A, Bellia F, et al. Noninvasive ventilation in pediatric emergency care: a literature review and description of our experience. *Expert Rev Respir Med*. 2013;7(5):545-552. **(Review)**
72. Contou D, Fragnoli C, Cordoba-Izquierdo A, et al. Non-invasive ventilation for acute hypercapnic respiratory failure: intubation rate in an experienced unit. *Respir Care.* 2013;58(12):2045-2052. **(Observational cohort; 242 patients)**
73. Pacilli AM, Valentini I, Carbonara P, et al. Determinants of noninvasive ventilation outcomes during an episode of acute hypercapnic respiratory failure in chronic obstructive pulmonary disease: the effects of comorbidities and causes of respiratory failure. *Biomed Res Int*. 2014;2014:976783. **(Prospective; 176 patients)**
74. Antonaglia V, Ferluga M, Capitanio G, et al. Respiratory mechanics in COPD patients who failed non-invasive

ventilation: role of intrinsic PEEP. *Respir Physiol Neurobiol.* 2012;184(1):35-40. **(Prospective; 29 patients)**
75. Savi A, Gasparetto Maccari J, Frederico Tonietto T, et al. Influence of FIO_2 on $PaCO_2$ during noninvasive ventilation in patients with COPD. *Respir Care.* 2014;59(3):383-387. **(Prospective; 17 patients)**
76. Galindo-Filho VC, Brandao DC, Ferreira Rde C, et al. Noninvasive ventilation coupled with nebulization during asthma crises: a randomized controlled trial. *Respir Care*. 2013;58(2):241-249. **(Randomized controlled; 21 patients)**
77. Carvalho L, Carneiro R, Freire E, et al. Non-invasive ventilation in cardiogenic pulmonary edema in the emergency department. *Rev Port Cardiol.* 2008;27(2):191-198. **(Retrospective observational; 17 patients)**
78. Cosentini R, Brambilla AM, Aliberti S, et al. Helmet continuous positive airway pressure vs oxygen therapy to improve oxygenation in community-acquired pneumonia: a randomized, controlled trial. *Chest.* 2010;138(1):114-120. **(Multicenter randomized controlled trial; 47 patients)**
79. Confalonieri M, Gazzaniga P, Gandola L, et al. Haemodynamic response during initiation of non-invasive positive pressure ventilation in COPD patients with acute ventilatory failure. *Respir Med.* 1998;92(2):331-337. **(Prospective observational; 19 patients)**
80. Peter JV, Moran JL, Phillips-Hughes J, et al. Effect of non-invasive positive pressure ventilation (NIPPV) on mortality in patients with acute cardiogenic pulmonary oedema: a meta-analysis. *Lancet.* 2006;367(9517):1155-1163. **(Meta-analysis; 23 studies)**
81. Liesching T, Nelson DL, Cormier KL, et al. Randomized trial of bilevel versus continuous positive airway pressure for acute pulmonary edema. *J Emerg Med.* 2014;46(1):130-140. **(Randomized; 27 patients)**
82. Agarwal R, Aggarwal AN, Gupta D. Role of noninvasive ventilation in acute lung injury/acute respiratory distress syndrome: a proportion meta-analysis. *Respir Care.* 2010;55(12):1653-1660. **(Systematic review; 13 studies)**
83. Zhan Q, Sun B, Liang L, et al. Early use of noninvasive positive pressure ventilation for acute lung injury: a multicenter randomized controlled trial. *Crit Care Med.* 2012;40(2):455-460. **(Multicenter randomized controlled; 40 patients)**
84. Quill CM, Quill TE. Palliative use of noninvasive ventilation: navigating murky waters. *J Palliat Med.* 2014;17(6):657-661. **(Case report; 4 patients)**
85. Peters SG, Holets SR, Gay PC. High-flow nasal cannula therapy in do-not-intubate patients with hypoxemic respiratory distress. *Respir Care.* 2013;58(4):597-600. **(Prospective; 50 patients)**
86. Azoulay E, Kouatchet A, Jaber S, et al. Noninvasive mechanical ventilation in patients having declined tracheal intubation. *Intensive Care Med.* 2013;39(2):292-301. **(Prospective observational cohort; 780 patients)**
87. Bulow HH, Thorsager B. Non-invasive ventilation in do-not-intubate patients: five-year follow-up on a two-year prospective, consecutive cohort study. *Acta Anaesthesiol Scand.* 2009;53(9):1153-1157. **(Retrospective observational; 38 patients)**
88. Scarpazza P, Incorvaia C, Amboni P, et al. Long-term survival in elderly patients with a do-not-intubate order treated with noninvasive mechanical ventilation. *Int J Chron Obstruct Pulmon Dis.* 2011;6:253-257. **(Prospective observational; 54 patients)**
89. Servera E, Sancho J, Zafra MJ, et al. Alternatives to endotracheal intubation for patients with neuromuscular diseases. *Am J Phys Med Rehabil.* 2005;84(11):851-857. **(Prospective cohort; 17 patients)**
90. Bourke SC, Tomlinson M, Williams TL, et al. Effects of non-invasive ventilation on survival and quality of life in patients with amyotrophic lateral sclerosis: a randomised controlled trial. *Lancet Neurol.* 2006;5(2):140-147. **(Randomized controlled; 92 patients)**
91. Wanek S, Mayberry JC. Blunt thoracic trauma: flail chest, pulmonary contusion, and blast injury. *Crit Care Clin.* 2004;20(1):71-81. **(Review)**
92. Uretzky G, Cotev S. The use of continuous positive airway pressure in blast injury of the chest. *Crit Care Med.* 1980;8(9):486-489. **(Case report)**
93. Chiumello D, Coppola S, Froio S, et al. Noninvasive ventilation in chest trauma: systematic review and meta-analysis. *Intensive Care Med.* 2013;39(7):1171-1180. **(Systematic review; 10 studies)**
94. McIlwaine M, Button B, Dwan K. Positive expiratory pressure physiotherapy for airway clearance in people with cystic fibrosis. *Cochrane Database Syst Rev.* 2015;6:CD003147. **(Cochrane review; 26 studies)**
95. Moran F, Bradley JM, Piper AJ. Non-invasive ventilation for cystic fibrosis. *Cochrane Database Syst Rev.* 2013;4:CD002769. **(Cochrane review; 7 studies, 106 patients)**
96. Armstrong D. The use of continuous positive airway pressure or non-invasive ventilation as forms of respiratory support in children with cystic fibrosis. *Paediatr Respir Rev.* 2013;14 Suppl 1:19-21. **(Review; 22 references)**
97. Constantin JM, Schneider E, Cayot-Constantin S, et al. Remifentanil-based sedation to treat noninvasive ventilation failure: a preliminary study. *Intensive Care Med.* 2007;33(1):82-87. **(Prospective; 13 patients)**
98. Rocco M, Conti G, Alessandri E, et al. Rescue treatment for noninvasive ventilation failure due to interface intolerance with remifentanil analgosedation: a pilot study. *Intensive Care Med.* 2010;36(12):2060-2065. **(Prospective; 36 patients)**
99. Huang Z, Chen YS, Yang ZL, et al. Dexmedetomidine versus midazolam for the sedation of patients with non-invasive ventilation failure. *Intern Med.* 2012;51(17):2299-2305. **(Randomized controlled; 62 patients)**
100. Devlin JW, Al-Qadheeb NS, Chi A, et al. Efficacy and safety of early dexmedetomidine during noninvasive ventilation for patients with acute respiratory failure: a randomized, double-blind, placebo-controlled pilot study. *Chest*. 2014;145(6):1204-1212. **(Randomized controlled; 33 patients)**
101. American Society of Anesthesiologists Task Force on Sedation and Analgesia by Non-Anesthesiologists. Practice guidelines for sedation and analgesia by non-anesthesiologists. *Anesthesiology.* 2002;96(4):1004-1017. **(Task force recommendations)**
102. Remick J, Sacchetti A, Bages G, et al. Noninvasive positive pressure ventilation in procedural sedation. *Am J Emerg Med.* 2010;28(6):750 e751-e753. **(Case report)**
103. Strayer RJ, Caputo ND. Noninvasive ventilation during procedural sedation in the ED: a case series. *Am J Emerg Med.* 2015;33(1):116-120. **(Case series; 11 patients)**
104. Landoni G, Cabrini L. Noninvasive ventilation outside the ICU. In: JL V, ed. *Annual Update of Intensive Care and Emergency Medicine.* Berlin, Heidelberg: Springer-Verlag; 2012:207-218. **(Textbook)**
105. Cabrini L, Antonelli M, Savoia G, et al. Non-invasive ventilation outside of the intensive care unit: an Italian survey. *Minerva Anestesiol.* 2011;77(3):313-322. **(Survey questionnaire; 46 hospitals)**

CME Questions

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1. **You are treating a patient with hypoxic respiratory failure in the ED, and the respiratory therapist asks you how to approach improving your patient's oxygenation. What would you tell the therapist?**
   a. Increase the respiratory rate of the patient
   b. Increase the tidal volume of the patient
   c. Increase the peak end-expiratory pressure of the patient
   d. Increase the pH of the patient

2. **You are treating a patient who presents with respiratory distress from congestive heart failure. Her initial vital signs are: blood pressure, 80/50 mm Hg; heart rate, 120 beats/min; respiratory rate, 30 breaths/min; oxygen saturation, 91% on 15-L face mask. Would NIV be indicated?**
   a. Yes, because she is tachypneic.
   b. Yes, because she is tachycardic and NIV will reduce stress on her cardiac function.
   c. No, because she is hemodynamically unstable.
   d. No, because she is hypoxic.

3. **A fully vaccinated 3-year-old boy presents with a temperature of 39°C. He is drooling copiously. Would a trial of NIV be beneficial in this patient?**
   a. No. Pediatric patients should not be on NIV until more ED-related literature is available.
   b. No. Excess respiratory secretions is an absolute contraindication for NIV.
   c. Yes. This patient is likely septic.
   d. Yes. If he is on NIV, you won't have to monitor him so closely.

4. **Which NIV mask type might be the best choice in treatment of a patient with obstructive sleep apnea and chronic obstructive pulmonary disease?**
   a. Nasal mask and nasal pillow
   b. Oronasal mask
   c. Cephalic mask
   d. Helmet

5. **According to the current literature, which subgroups of patients with chronic obstructive pulmonary disease (COPD) exacerbations have increased benefit from NIV?**
   a. Those with mild forms of COPD, such as patients who have never been hospitalized
   b. Those with GCS score of ≤ 3
   c. Those with pH > 7.4 at time of therapy
   d. Those with APACHE II score < 29

6. **You are treating a 17-year-old asthmatic patient with an acute asthma exacerbation and have decided to try BPAP. While observing the patient, he suddenly begins to vomit. What is the next most appropriate step in management?**
   a. Suction the patient and continue albuterol treatments via NIV.
   b. Prepare to intubate the patient.
   c. Increase the IPAP and observe.
   d. Give the patient epinephrine intramuscularly and observe.

7. **In which patient scenario would NIV NOT be recommended for trial?**
   a. A patient who presents with an asthma exacerbation
   b. A patient who presents with an acute exacerbation of cystic fibrosis
   c. A patient who presents with severely symptomatic submersion injury
   d. A patient with a do-not-intubate order

8. **Which of the following is NOT one of the 3 factors found to be predictive of NIV failure?**
   a. Altered mental status
   b. Respiratory failure that is not acute-on-chronic
   c. Acidosis with pH < 7.3
   d. Severe hypoxemia

Coming Soon in *Emergency Medicine Practice*

Sedative Hypnotic Withdrawal Syndrome: Recognition And Treatment

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Sedative hypnotic drugs are commonly used to treat anxiety and insomnia, and include benzodiazepines and barbiturates (gamma-aminobutyric acid [GABA]-ergic agents) as well as gamma-hydroxybutyric acid (GHB), gamma-hydroxybutyrolactone (GBL), baclofen, and ethanol. As the chronic use of these drugs (both for medical and nonmedical reasons) has increased in the United States to near-epidemic proportions, emergency departments are seeing an increase in patients suffering from withdrawal. Many of the same biochemical and neurologic processes involved in alcohol dependence, tolerance, and withdrawal are seen in withdrawal from other GABAergic agents. These withdrawal syndromes can include anxiety, tremor, diaphoresis, palpitations, gastrointestinal upset, and insomnia. With some patients, symptoms may progress to hallucinations, delusions, and delirium. This issue reviews optimal management of withdrawal symptoms based upon the drug causing the withdrawal and the severity of the syndrome. Management of special populations, such as trauma patients, critically ill patients, elderly patients, and patients with cardiovascular disease are also reviewed.

In upcoming issues of
Emergency Medicine Practice....

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- Sedative/Hypnotic Withdrawal
- Lower Extremity Dislocations
- Decompensated Heart Failure
- Spontaneous Bacterial Peritonitis
- Renal and Genitourinary Trauma
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Target Audience: This enduring material is designed for emergency medicine physicians, physician assistants, nurse practitioners, and residents.

Goals: Upon completion of this activity, 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 presentations; and (3) describe the most common medicolegal pitfalls for each topic covered.

Objectives: Upon competion of this article, you should be able to: (1) list the contraindications to use of NIV; (2) identify patients with respiratory failure who may benefit from NIV; (3) describe the various masks and modalities of NIV; and (4) describe signs of NIV failure.

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