Noninvasive Ventilation for the Emergency Physician

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KEYWORDS

- Noninvasive ventilation • Acute respiratory failure
- Continuous positive airway pressure • Bilevel positive airway pressure
- High flow nasal cannula

KEY POINTS

- Bilevel positive airway pressure (BPAP) should be used in all cases of moderate to severe respiratory failure owing to exacerbations of chronic obstructive pulmonary disease.
- Continuous positive airway pressure or BPAP can be used in patients with acute exacerbations of cardiogenic pulmonary edema.
- Noninvasive monitoring (NIV) can be attempted in patients with asthma, traumatic respiratory failure, respiratory failure associated with immunosuppression, and community-acquired pneumonia.
- High-flow nasal cannula is an emerging therapy that may be useful to treat hypoxic respiratory failure.
- Patients started on NIV should be monitored closely. Signs and symptoms should be evaluated after 1 hour of NIV to determine success or failure of therapy.

INTRODUCTION

Emergency physicians (EPs) routinely evaluate and manage patients with acute respiratory failure (ARF). Noninvasive ventilation (NIV) delivers positive pressure ventilation through a tight-fitting mask and is an invaluable tool in the treatment of select emergency department (ED) patients with ARF. The use of NIV is associated with decreased rates of intubation and mortality.[1,2] Importantly, the use of NIV requires knowledge of appropriate patient selection, modes of delivery, selection of the correct amount of positive pressure, and appropriate methods of monitoring the patient.

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Inappropriate and indiscriminate use of NIV can be fraught with pitfalls in patient care. It is imperative that the EP be knowledgeable about the use of NIV in ED patients with ARF. This article discusses the primary modes of NIV, traditional and novel applications of NIV, and practical considerations when initiating NIV.

MODES OF NONINVASIVE VENTILATION

There are 2 modes of NIV: continuous positive airway pressure (CPAP) and bilevel positive airway pressure (BPAP). In CPAP, the provider sets a single pressure that is applied during all phases of the respiratory cycle; it is analogous to the positive end-expiratory pressure (PEEP) set during invasive mechanical ventilation, and often these terms are used interchangeably. CPAP is most useful for patients who primarily have hypoxic respiratory failure. In contrast with CPAP, BPAP delivers 2 levels of pressure to the patient: inspiratory positive airway pressure (IPAP) and expiratory positive airway pressure (EPAP). EPAP is analogous to the pressure that patients receive during CPAP; in BPAP modes, EPAP and PEEP are typically used interchangeably. When a breath is initiated in BPAP, the patient receives the set IPAP. The IPAP has 2 components: the EPAP and the pressure support (PS) that is provided in addition to the EPAP. The additive pressures of EPAP and PS equal the IPAP (**Table 1**). BPAP can be useful for patients with both hypercapnic and hypoxic respiratory failure.

Recently, the high-flow nasal cannula (HFNC) has emerged as a method to deliver NIV through a nasal cannula rather than a tight-fitting face mask. HFNC devices deliver humidified oxygen at high flow rates to achieve high oxygen concentrations. The device has been better studied in patients with hypoxic respiratory failure, but there remains interest in using it for hypercapnic respiratory failure. The manner in which HFNC affects pulmonary physiology, either through dead space washout, by applying some small level of positive airway pressure, or another unknown mechanism, remains incompletely understood.[3]

PHYSIOLOGIC CHANGES WITH NONINVASIVE VENTILATION

To provide comprehensive care to critically ill patients, it is important for the EP to understand the pulmonary and cardiovascular changes that occur with NIV. The goal of NIV is to decrease the patient's work of breathing and improve pulmonary gas exchange. Often, a gestalt visual assessment of respiratory effort is used to describe the work of breathing. However, it is actually determined by a complicated

Table 1
Common acronyms in noninvasive ventilation

Acronym	Definition
NIV	Noninvasive ventilation
CPAP	Continuous positive airway pressure
BPAP	Bilevel positive airway pressure
PEEP	Positive end-expiratory pressure
iPEEP	Intrinsic positive end-expiratory pressure
EPAP	End positive expiratory pressure (= PEEP)
PS	Pressure support
IPAP	Inspiratory positive airway pressure (= PS + PEEP or PS + EPAP)
HFNC	High-flow nasal cannula

physiologic calculation that involves tidal volume and airway pressure. When positive pressure is applied, the work of breathing can decrease by 60% through several different mechanisms.[4] Application of CPAP or PEEP reduces the work of breathing by counteracting the patient's intrinsic PEEP. PS reduces work of breathing by decreasing the patient's contribution to the transpulmonary pressure during inspiration. PS and PEEP help to overcome atelectasis, decrease oxygen consumption by the respiratory muscles, and improve expiratory tidal volumes.[4] These changes improve ventilation–perfusion matching (V/Q), improve oxygenation, and allow more effective carbon dioxide removal.

A positive pressure breath affects the circulatory system by altering the dynamics of intrathoracic pressure. Increases in intrathoracic pressure impede venous return and reliably decrease the effective preload. For patients who are preload dependent, this change from negative pressure to positive pressure breathing can result in hypotension. Increases in intrathoracic pressure also assist the left ventricle by lowering cardiac afterload. By providing positive intrathoracic pressure, the left ventricle has less transmural wall stress during systole, allowing the myocardium to work more efficiently. Circulatory changes occurring with the addition of positive pressure ventilation can decrease both preload and afterload; this can be helpful in cases of acute cardiogenic pulmonary edema (ACPE), but must be applied cautiously in patients who might be preload dependent.

TRADITIONAL APPLICATIONS OF NONINVASIVE VENTILATION

Chronic Obstructive Pulmonary Disease

Acute exacerbations of chronic obstructive pulmonary disease (COPD) traditionally carried a high mortality rate—up to 33% of patients admitted to the hospital died despite appropriate therapy.[5–9] Patients with COPD have an expiratory airflow limitation owing to the collapse of small and medium-sized airways. When patients have acute exacerbations of COPD, they have difficulty with gas exchange and therefore retain carbon dioxide. Historically, the treatment of acute exacerbations of COPD consisted of the administration of bronchodilators, systemic corticosteroids, supplemental oxygen, and antibiotics. When all measures failed, patients were intubated and mechanically ventilated. Mortality rates and the frequency of intubation for patients with hypercapnic respiratory failure decreased once NIV became an option for treatment.

For patients with acute exacerbations of COPD, NIV is one of the most effective treatments to improve patient outcome. The mortality benefit of NIV has been assessed in a number of randomized controlled trials. A Cochrane review evaluated 10 studies that looked at patient mortality when NIV was used for COPD exacerbations. There was a significant benefit, with a number needed to treat (NNT) of just 10 to improve the mortality rate.[1]

With the development of NIV, practitioners recognized that using this therapy before patients reach the extremes of respiratory distress obviated the need for endotracheal intubation in many cases. The same Cochrane review examined the role of NIV to prevent endotracheal intubation in respiratory failure from COPD and found an NNT of just 4.[1] One in 4 patients was spared the need for sedation and invasive mechanical ventilation, which decreases the likelihood of a variety of ventilator-associated conditions that increase patient morbidity. Other outcomes shown to improve with the early application of NIV for COPD exacerbations include decreased hospital duration of stay, decreased complications, and improvements in pH, respiratory rate, and partial pressure of carbon dioxide in arterial blood ($Paco_2$).[1] BPAP

was the primary mode of NIV in the studies examined by this Cochrane review. No high-quality studies have evaluated CPAP for COPD. Recent guidelines on the use of NIV support the use of BPAP for patients with COPD and pH of less than 7.35.[10] NIV in the form of BPAP should be started early in the treatment of ED patients with acute COPD exacerbations.

Acute Cardiogenic Pulmonary Edema

Exacerbation of acute congestive heart failure resulting in ACPE is a leading cause of ARF in EDs in the United States. The in-hospital mortality rate for patients with ACPE can be as high as 12%.[11] A growing body of literature supports the use of NIV in patients with ACPE.

In patients with or without existing cardiomyopathy, increased left ventricular end-diastolic pressures cause the left atrium to pump against an increased load. As the atrium becomes overwhelmed, an increased hydrostatic pressure gradient is created within the pulmonary arterial and venous systems. Eventually, the pulmonary interstitium becomes overloaded, resulting in alveolar collapse and widening of the area reserved for diffusion of gases. Therapy for ACPE is aimed at reducing cardiac preload, reducing afterload, removing excess volume, and recruiting areas of lung with V/Q mismatch.

Initial studies on the use of NIV for ACPE were performed in the 1930s; however, subsequent investigations shifted focus to more invasive ventilatory strategies. It was not until the publication of several case series in the 1970s that interest in NIV for ACPE resurfaced.[12] Clinical practice guidelines now strongly recommend the use of NIV for ACPE.[10] Similar to patients with acute COPD exacerbations, patients presenting with ACPE have a lower mortality rate when NIV is initiated early in their management. A Cochrane systematic review and metaanalysis found an NNT of 13 to improve mortality when NIV was compared with standard therapy for ACPE.[2] Interestingly, when CPAP and BPAP were compared individually with standard therapy, only CPAP demonstrated a statistical improvement in mortality (with an NNT of 9). In contrast, when the metaanalysis compared CPAP with BPAP, no difference was found in the mortality rate.[2] Although the current literature is more robust for CPAP, EPs should feel comfortable initiating either CPAP or BPAP for patients with ACPE. It might be reasonable to choose a NIV modality based on the presence of hypercapnia. Patients with ACPE and hypercapnia both have better outcomes with BPAP, and patients with ACPE without hypercapnia will see the consistent benefits of CPAP.[2] The authors favor the use of BPAP in patients with ACPE and hypercapnia, whereas patients with ACPE without hypercapnia may derive benefit from CPAP.

In addition to mortality, NIV has been shown to improve other outcomes in patients with ACPE. A Cochrane review of 22 trials found a decreased rate of endotracheal intubation (NNT of 8), decreased the length of stay in the intensive care unit, and decreased respiratory rate among patients receiving NIV. Interestingly, there were no improvements in heart rate, systolic blood pressure, diastolic blood pressure, or mean arterial pressure.[2] There had been concern that BPAP, compared with CPAP, might increase the incidence of acute myocardial infarction in patients with ACPE, but recent reports do not support this association.

NOVEL APPLICATIONS OF NONINVASIVE VENTILATION

Asthma Exacerbations

Given the similarities between asthma and COPD with respect to obstructive airway pathophysiology, it seems logical that NIV would improve outcomes in patients with

acute exacerbations of asthma. However, no studies have demonstrated improved morbidity or mortality rates from the use of NIV in patients with asthma.

Asthma is a disease marked by the pathologic triad of airflow obstruction, mucus hypersecretion, and bronchoconstriction. Exacerbations of asthma can be caused by infection, medication nonadherence, environmental allergens, and exposure to cigarette smoke. Treatment of the patient with an acute asthma exacerbation centers on the administration of inhaled bronchodilators and systemic corticosteroids. Additional therapies that can be considered include intramuscular bronchodilators, magnesium sulfate, helium–oxygen admixture, and NIV.

There is a dearth of literature on the use of NIV in acute asthma exacerbations. A 2012 Cochrane review on NIV for acute asthma exacerbations states that "this course of treatment remains controversial."[13] A 2011 clinical practice guideline from the Canadian Critical Care Trials Group "make(s) no recommendation about the use of noninvasive positive-pressure ventilation in patients who have an exacerbation of asthma, because of insufficient evidence."[10] No randomized trial has evaluated the use of CPAP in asthma patients. Three small, randomized trials evaluated BPAP in asthma. Holley and colleagues[14] compared 19 patients placed on BPAP for asthma with 16 patients who received standard therapy. None of the patients in this study died; 1 patient in the BPAP group and 2 in the control group required intubation. The study was stopped early owing to poor enrollment. In the second study, Soroksky and colleagues[15] compared BPAP with standard therapy in 15 patients. No patients died or were intubated. In the third study, Soma and colleagues[16] analyzed 26 patients who received BPAP compared with 14 patients in a control arm. No patients died or were intubated.

Although the benefit of NIV in asthma has not been demonstrated in large, multicenter randomized trials, no demonstrable harm from this intervention has been detected. Its routine use cannot be recommended, but, in select cases of severe asthma, NIV should be considered.

Traumatic Respiratory Failure

Patients with blunt chest injury are at high risk for respiratory failure. In the trauma patient, endotracheal intubation and mechanical ventilation are associated with high rates of ventilator-associated pneumonia and prolonged use of mechanical ventilation.[17] Observational trials and several small, randomized studies have assessed the use of NIV in blunt chest trauma, yielding mixed results. A 2013 systematic review concluded that the early use of NIV in blunt chest trauma could be considered.[18] This recommendation is based on 1 medium-sized randomized trial that had improved rates of intubation in patients with chest trauma and hypoxemia (ratio of arterial oxygen partial pressure to fractional inspired oxygen [P/F ratio] <200) when managed with NIV compared with a nonrebreather mask.[19] Patients who develop respiratory failure later in their course (after 48 hours) are unlikely to benefit from NIV, so its use is not recommended.[18] Select patients with thoracic trauma who have hypoxic respiratory failure within the first 48 hours after trauma might benefit from BPAP. The available evidence does not support NIV as rescue therapy in patients with chest trauma who develop respiratory failure.

Community-Acquired Pneumonia

There is great interest in using NIV for patients with community-acquired pneumonia (CAP) to avoid the complications of invasive mechanical ventilation. Unfortunately, the literature on NIV for patients with CAP has produced mixed results. Prospective trials have demonstrated failure rates as high as 50%.[20–26] Studies that demonstrated lower rates of intubation with NIV in CAP primarily included patients who had less severe

disease and responded to initial medical therapy.[26] A single, randomized, controlled trial evaluating standard therapy and standard therapy plus NIV in 56 patients with CAP found no improvement in the mortality rate. Patients who received NIV did have lower rates of intubation and shorter lengths of stay in an intermediate care unit.[27] An additional randomized, controlled trial evaluated patients with ARF of varying causes. In this study, patients with CAP who were treated with NIV had lower intubation rates and a lower mortality rate in the intensive care unit.[28]

Results from additional studies have demonstrated less favorable results, causing confusion about the role of NIV in patients with respiratory failure from CAP. As a result of the ambiguity in evidence, current guidelines do not provide a recommendation about the use of NIV in CAP.[10] If it is used, patients with less severe disease who show an early response to therapy might achieve benefit from NIV. It should be used with caution in patients with CAP.

Immunocompromised Patients

Treatment of ARF in the immunocompromised patient is fraught with difficulty. Immunosuppressed patients are at high risk for infectious complications of endotracheal intubation and mechanical ventilation. In a cohort of solid organ transplant patients with respiratory failure, Antonelli and colleagues[29] demonstrated decreased rates of intubation and mortality in the intensive care unit in patients randomized to NIV compared with standard therapy. Hilbert and colleagues[30] compared NIV with standard therapy in immunocompromised patients with pneumonia. Patients who received NIV for 3 hours, followed by a 3-hour period without NIV, had fewer intubations and decreased mortality. More recent data from a multicenter database of patients with hematologic malignancies demonstrated similar mortality rates between patients treated initially with NIV and those treated initially with mechanical ventilation.[31] Importantly, more than 50% of patients treated initially with NIV did not require intubation. Based on the available evidence, NIV guidelines recommend the use of BPAP in immunosuppressed patients with pneumonia.[10] It is important to recognize that the rate of NIV failure is higher for this patient population compared with other diseases, such as exacerbations of COPD and ACPE.

Delayed Sequence Intubation

Endotracheal intubation of the critically ill patient with hypoxia is difficult and fraught with the potential for morbidity and mortality. Some practitioners use NIV after sedation to recruit areas of lung with shunt physiology to improve the chance of successful endotracheal intubation without further hypoxia.[32] A prospective case series in the ED setting describes the successful application of this technique in patients presenting with acute hypoxic respiratory failure.[33] Misinterpretation of this technique has led some to view it as a way to avoid intubation. It should be emphasized that this approach to the patient in respiratory failure is not meant as a way to avoid intubation, but as a mechanism to provide safer conditions for it. If the patient fails to improve or worsens, the clinician should be ready to perform immediate intubation; if the patient improves, a more controlled intubation can be attempted.

CONTROVERSIAL USES OF NONINVASIVE VENTILATION

Altered Mental Status

Altered mental status is often mentioned as an absolute or relative contraindication to NIV. An international consensus conference even recommended that NIV not be used in patients with a Glasgow Coma Scale score of less than 10.[34] The principle behind

this dogma is that altered patients could be unable to protect their airway and thus are at risk for aspiration. Many of the larger studies on NIV have excluded patients with any evidence of altered mental status. However, 2 studies evaluated NIV in patients with varying levels of mentation. The first examined 958 patients who received NIV. Investigators retrospectively determined patients' Glasgow Coma Scale score at the time NIV was initiated. They then compared patients with a Glasgow Coma Scale score of less than 8 with those with a score of greater than 8. The rates of intubation and mortality did not differ between the 2 groups.[35] A second study of 80 patients evaluated only altered patients with COPD. In this study, there was no difference in outcome between altered patients with a low mental status and those with normal mental status.[36] Based on available evidence, it seems reasonable to attempt a trial of NIV in select patients with altered mentation. Importantly, the cause of the alteration in mental status might portend different outcomes when using NIV. In the limited literature that is available currently, the highest success rates of NIV were achieved in altered patients with an acute COPD exacerbation.

Acute Respiratory Distress Syndrome

The acute respiratory distress syndrome (ARDS) describes a constellation of findings in patients with ARF. The Berlin Definition of ARDS defines the syndrome as ARF that occurs over 7 days and is marked by the presence of bilateral opacities on radiographic imaging, a partial pressure of oxygen in arterial blood (Pa_{O_2})/fraction of inspired oxygen (Fi_{O_2}) ratio of less than 300, the absence of left heart failure as a significant contributor to the respiratory failure, and the need for 5 cm H_2O of PEEP.[37] Patients with ARDS have a high mortality rate. Studies evaluating the use of NIV in patients with ARDS have shown failure rates of approximately 50%. ARDS is not diagnosed commonly in the ED, primarily because the constellation of clinical, laboratory, and radiographic findings is not apparent in the first hours of presentation. For the EP, NIV should not be used in the hypoxic patient who has a clinical picture consistent with ARDS.

PRACTICAL CONSIDERATIONS FOR INITIATING NONINVASIVE VENTILATION

Once a patient is selected for treatment with NIV, the EP must choose the mode of ventilation, the type of interface, the PEEP or CPAP level, the IPAP or PS level, and the Fi_{O_2} (**Box 1**). The selection of the NIV mode primarily depends on the clinical indication. BPAP remains a viable option for all disease states, and CPAP remains a highly effective therapy for patients with ACPE.

The NIV interface is usually determined by the availability of masks. Five types are available: nasal masks, nasal pillows, full face masks, total face mask, and helmets. The 2 most common interfaces are nasal masks and full face masks.[38] Despite head-to-head comparisons, a comment from an article published more than 2 decades ago remains timely: "The optimal interface and ventilator design have not been determined, and these may differ among patients."[39] Patients often complain about the tightness of the interface when it is first applied. Caution should be used when providing any patient on NIV a sedative or hypnotic medication to improve compliance with therapy. Allowing the anxious patient to hold the mask in place while low amounts of PEEP are first applied (3–5 cm H_2O) is a technique these authors have used with some anecdotal success.

When setting CPAP or PEEP, a common practice is to begin with 5 cm H_2O. PEEP can be titrated every 10 to 15 minutes by increasing pressure by 2 cm H_2O, with a goal of improving the SpO_2 or Pa_{O_2}. It is reasonable to start higher, around 8 to 12 cm H_2O,

Box 1
Practical considerations when initiating NIV

1. Choose CPAP or BPAP modality based on indication
2. Select interface/mask depending on local availability

CPAP	*BPAP*
3. Set CPAP 5–10 cm H_2O	3. Set EPAP or PEEP 5–8 cm H_2O
4. Set Fio_2 between 0.4 and 1.0	4. Set PS (7–10 cm H_2O) or IPAP (12–15 cm H_2O)
5. Titrate pressure 2 cm H_2O every 5 min to effect	5. Set Fio_2 between 0.4 and 1.0
	5. Titrate pressures 2 cm H_2O every 5 min to effect
6. Titrate Fio_2 according to SaO_2 or ABG	6. Titrate Fio_2 according to SaO_2 or ABG

Abbreviations: ABG, arterial blood gases; BPAP, bilevel positive airway pressure; CPAP, continuous positive airway pressure; EPAP, expiratory positive airway pressure; Fio_2, fraction of inspired oxygen; IPAP, inspiratory positive airway pressure; NIV, noninvasive ventilation; PEEP, positive end-expiratory pressure; PS, pressure support; SaO_2, oxygen saturation.

when providing CPAP therapy for ACPE (studies that found a benefit to CPAP used these initial levels).[2] Health care providers should be mindful of the influence of PEEP on cardiac preload, because rapid titration could result in hypotension. Inspiratory pressures are set using the IPAP or PS. Many of the higher quality studies in the aforementioned Cochrane reviews used IPAP settings of 12 to 15 cm H_2O, which equates to a PS of 7 to 10 above the set PEEP.[1,2] As peak inspiratory pressures approach 20 to 25 cm H_2O, the practitioner should be aware of the increasing chance for gastric insufflation. The lower esophageal sphincter tone in normal patients is about 25 cm H_2O and can be lower in critically ill patients. At these inspiratory pressure levels, the risks of inducing vomiting and subsequent aspiration should be weighed against further benefits of added PS or PEEP.

Fio_2 can be set anywhere in the range of 21% to 100%. For patients requiring an Fio_2 of greater than 80% while receiving a PEEP of 5 cm H_2O, it is reasonable to increase PEEP to 8 to 10 cm H_2O to recruit areas with physiologic shunting and decrease the theoretic risks of oxygen toxicity.[40]

PREDICTING THE SUCCESS OR FAILURE OF NONINVASIVE VENTILATION

Despite the early application of NIV, some patients eventually require endotracheal intubation and mechanical ventilation. Depending on the clinical indication for NIV, the likelihood of failure varies dramatically. As discussed, 80% of patients with acute exacerbations of COPD can be managed successfully with NIV, whereas 50% of immunocompromised patients may require intubation. Thus, clinical indication remains as a robust predictor of success.[20] The ability to predict which patients will fail NIV and require intubation is critical. Frequent reassessment of patients on NIV is necessary, and the clinical variables listed in **Table 2**, which indicate the likelihood of success or failure, should be assessed after 30 to 60 minutes of treatment.[20,41]

HIGH-FLOW NASAL CANNULA

Providing supplemental oxygen using a nasal cannula has been standard therapy for hypoxic patients for decades. The amount of supplemental oxygen delivered with a traditional nasal cannula ranges from 25% to 35%.[42] Beginning in the early

Table 2
Predictors of the failure or success of NIV after 1 hour

Failure	Success
Sepsis as a cause of the respiratory failure	Improving pH
ARDS	Improving $Paco_2$
Higher severity score (SAPS II)	Improving Pao_2/Fio_2 ratio

Abbreviations: ARDS, acute respiratory distress syndrome; Fio_2, fraction of inspired oxygen; NIV, noninvasive ventilation; $Paco_2$, partial pressure of carbon dioxide in arterial blood; Pao_2, partial pressure of oxygen in arterial blood; SAPS, Simplified Acute Physiology Score.

1990s, there was interest in using higher flow rates to produce a greater oxygen concentration through HFNC devices, which consist of a specialized nasal cannula, an oxygen delivery device, and a humidification system. Studies have tested humidified HFNC delivery systems against nonrebreather masks, finding that the HFNC system can deliver higher Fio_2 concentrations than nonrebreather masks at the same flow rates.[43] Commercial high-flow devices became available in the early 2000s and their use in adult patients has expanded dramatically since that time.

As use of HFNC devices became more common, questions were raised about the ability of this modality to provide a level of positive airway pressure. Initial reports evaluated healthy adult volunteers to quantify the capability of HFNC devices to generate positive airway pressure.[44,45] In these studies, a pressure transducer was fitted to a nasopharyngeal catheter, which sat in the posterior pharyngeal space as the supplemental oxygen was provided. Groves and Tobin[44] varied the HFNC flow between 10 and 60 L/min and measured pressures when the subject's mouth was closed and open. The posterior pharyngeal pressures rose linearly from 3.7, 7.2, and 8.7 cm H_2O when respective flows of 20, 40, and 60 L/min were used. Pressure measurements obtained in a mouth open situation decreased to 1.4, 2.2, and 2.7 cm H_2O using the same levels of flow. The Park group maintained a constant 35 L/min flow and found the mean pharyngeal pressure to be 2.7 cm H_2O with the mouth closed and 1.2 cm H_2O when the mouth was open. In contrast with CPAP, the pressure waveform decreased to zero during inspiration.[45] These physiologic studies suggest that any positive pressure effect of HFNC is meager and dissipates with open mouth breathing and during inspiration.

HFNC systems have been used in a number of scenarios, and their effects on clinical variables have been reported in the literature based on observational studies and prospective comparisons with face mask devices. When used in patients with mild to moderate hypoxemia, HFNC devices are well-tolerated, provide a reliable improvement in Pao_2, and reduce patients' respiratory rate.[3] Oxygenation via an HFNC seems to be an attractive and viable option for patients with hypoxemic respiratory failure and in patients after cardiac surgery.[46,47] At present, these devices should not be used as first-line therapy for diseases such as COPD and ACPE, which clearly benefit from traditional NIV modalities; they are also an attractive option for patients with hypoxemic respiratory failure. Future studies will likely elucidate the indications for use of these systems.

SUMMARY

ARF is commonly encountered in the ED. Select patients with ARF can be managed effectively with NIV. The best evidence for use of NIV comes from patients presenting

with acute exacerbations of COPD and ACPE. Less robust evidence is available for diseases such as asthma and immunocompromised respiratory failure; in these cases, a trial of NIV can be considered. Patients with diseases such as traumatic respiratory failure, ARDS, and CAP are not likely to benefit from NIV. BPAP and CPAP are the most commonly used modes of NIV, and practitioners should be aware of the beneficial and detrimental physiologic changes associated with their use. Oxygenation via HFNC is an attractive option to treat the hypoxic patient, but is not a replacement for NIV. Clinicians should be aware that failure of NIV is common, and its use requires vigilance and constant reassessment of the patient with respiratory failure.

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