CHEST Postgraduate Education Corner

CONTEMPORARY REVIEWS IN CRITICAL CARE MEDICINE

Noninvasive Ventilation for Critical Care*

Erik Garpestad, MD, FCCP; John Brennan, MD; and Nicholas S. Hill, MD, FCCP

Noninvasive ventilation (NIV), the provision of ventilatory assistance without an artificial airway, has emerged as an important ventilatory modality in critical care. This has been fueled by evidence demonstrating improved outcomes in patients with respiratory failure due to COPD exacerbations, acute cardiogenic pulmonary edema, or immunocompromised states, and when NIV is used to facilitate extubation in COPD patients with failed spontaneous breathing trials. Numerous other applications are supported by weaker evidence. A trial of NIV is justified in patients with acute respiratory failure due to asthma exacerbations and postoperative states, extubation failure, hypoxemic respiratory failure, or a do-not-intubate status. Patients must be carefully selected according to available guidelines and clinical judgment, taking into account risk factors for NIV failure. Patients begun on NIV should be monitored closely in an ICU or other suitable setting until adequately stabilized, paying attention not only to vital signs and gas exchange, but also to comfort and tolerance. Patients not having a favorable initial response to NIV should be considered for intubation without delay. NIV is currently used in only a select minority of patients with acute respiratory failure, but with technical advances and new evidence on its proper application, this role is likely to further expand. ***(CHEST 2007; 132:711–720)***

Key words: acute respiratory failure; COPD; mechanical ventilation; noninvasive ventilation

Abbreviations: ALI = acute lung injury; APACHE = acute physiology and chronic health evaluation; CHF = congestive heart failure; CI = confidence interval; CPAP = continuous positive airway pressure; CPE = cardiogenic pulmonary edema; DNI = do not intubate; F_{IO_2} = fraction of inspired oxygen; NIV = noninvasive ventilation; PEEP = positive end-expiratory pressure

One of the most important developments in the field of mechanical ventilation over the past 15 years has been the emergence of noninvasive ventilation (NIV) as an increasing part of the critical care armamentarium. Although similar techniques such as intermittent positive pressure breathing were used widely during previous decades, unlike NIV they were used mainly to provide intermittent aerosol therapy. The term *NIV* includes other forms of ventilatory assistance that avoid airway invasion, such as negative pressure ventilation, but the vast majority of NIV applications now use positive pressure. Noninvasive application of continuous positive airway pressure (CPAP) will be considered a form of "NIV" here when used to treat certain types of respiratory failure, but it is not a "true" form of ventilatory assistance because the positive pressure does not increase intermittently to assist inspiration.

The emergence of NIV has been fueled by its relative ease of application compared to alternative forms of noninvasive ventilation, as well as its demonstrated ability to improve patient outcomes in certain forms of acute respiratory failure compared to previously standard therapy, including endotra-

*From the Division of Pulmonary, Critical Care, and Sleep Medicine, Tufts-New England Medical Center, Boston, MA.

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Correspondence to: Nicholas S. Hill, MD, FCCP, Division of Pulmonary, Critical Care and Sleep Medicine, Tufts-New England Medical Center, 750 Washington St, Boston, MA 02111; e-mail: nhill@tufts-nemc.org

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cheal intubation.[1] This update will focus on recent developments regarding acute applications of NIV, including the expanding evidence base, technical advances, and assessment of current utilization. We emphasize techniques for proper patient selection and implementation that are critical if success rates reported in the literature are to be duplicated.

NIV for Acute Respiratory Failure

Recommended Indications

Many applications of NIV have been tried in the critical care setting, but as of yet, only four are supported by multiple randomized controlled trials and metaanalyses.

COPD Exacerbations

The strongest level of evidence, including multiple randomized controlled trials,[2–7] supports the use of NIV to treat exacerbations of COPD. Also, metaanalyses by Ram et al[8] and Keenan et al[9] demonstrate more rapid improvements in vital signs and gas exchange as well as reductions in the need for intubation (relative risk, 0.41; 95% confidence interval [CI], 0.33 to 0.53; risk reduction, 28%), decreased mortality (relative risk, 0.52; 95% CI, 0.35 to 0.76; risk reduction, 10%), and decreased hospital length of stay (-3.24 days; 95% CI, -4.42 to -2.06 days and -4.57 days, respectively). The Cochrane analysis[8] also noted more rapid improvements in vital signs, pH, and gas exchange, and reduced complication rates and hospital lengths of stay. Based on these observations, NIV should now be considered the ventilatory modality of first choice to treat acute respiratory failure caused by exacerbations of COPD.

Acute Cardiogenic Pulmonary Edema

Similarly strong evidence supports the use of noninvasive positive pressure techniques to treat acute cardiogenic pulmonary edema (CPE).[10–17] Recent metaanalyses[18–20] on the use of NIV to treat acute pulmonary edema have shown that both CPAP and NIV lower intubation and mortality rates compared to conventional therapy with oxygen, although the reduction in mortality rate was statistically significant only in one of the metaanalyses.[20]. A randomized trial[17] comparing CPAP directly to NIV showed no difference in outcomes between the two to treat CPE, a finding confirmed in a recent metaanalysis by Ho and Wong.[21] Accordingly, by virtue of its greater simplicity and lesser expense, CPAP has been suggested as the initial noninvasive choice for acute CPE. However, some studies[22] have observed more rapid improvements in gas exchange and vital signs with NIV than with CPAP alone, so NIV may be preferable for patients with persisting dyspnea or hypercapnia after initiation of CPAP.

Facilitating Extubation in COPD Patients

Another NIV application supported by multiple randomized trials is to facilitate extubation in COPD patients. Candidates for early extubation are those who were intubated for COPD exacerbations because they were poor candidates for or failed NIV initially and are unable to pass a T-piece trial even though they have improved sufficiently to tolerate NIV. Ferrer et al[23] confirmed earlier findings of Nava et al[24] in such patients, randomizing 43 patients with "persistent" weaning failure (failure of three consecutive T-piece trials) to be extubated to NIV or weaned using conventional methods. They observed that NIV-treated patients had shorter durations of intubation (9.5 days vs 20.1 days) and ICU (14 days vs 25 days) and hospital stays (14.6 days vs 40.8 days), decreased incidence of nosocomial pneumonia (24% vs 59%), and improved ICU and 90-day survivals (80% vs 50%) [all $p < 0.05$]. These studies strongly support the use of NIV to facilitate extubation in patients with hypercapnic respiratory failure and to avoid the complications of prolonged intubation. But it must be applied cautiously: only in patients who are otherwise good candidates for NIV and were not difficult intubations.

Immunocompromised Patients

The use of NIV is also well supported for immunocompromised patients who are at high risk for infectious complications from endotracheal intubation, such as those with hematologic malignancies, AIDS, or following solid-organ or bone marrow transplants. In a randomized trial[25] of patients with hypoxemic respiratory failure following solid-organ transplantation, NIV use decreased intubation rate (20% vs 70%, $p = 0.002$) and ICU mortality (20% vs 50%, $p = 0.05$) compared with conventional therapy with oxygen. Hilbert et al[26] observed fewer intubations (46% vs 77%) and a lower mortality rate (50% vs 81%) [both $p < 0.05$] among immunocompromised patients (mainly hematologic malignancies, but some after solid-organ transplantation or with AIDS) with acute respiratory failure randomized to NIV as opposed to conventional therapy. The sizable reductions in mortality in these studies strongly support the early use of NIV as the initial ventilatory modality in immunocompromised patients with acute respiratory failure, although morbidity and mortality rates are still likely to be high.