Clinical practice guidelines for use of noninvasive ventilation for acute respiratory failure

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The use of noninvasive ventilation (NIV) has increased considerably over the last two decades and is now widespread in the acute-care setting for management of acute respiratory failure (ARF). A guideline committee selected 11 questions relating to the clinical application of NIV for various etiologies of ARF based on their perceived clinical importance, and assessed the evidence currently available to develop corresponding recommendations [1].

Take-away messages

The use of NIV is widespread in the acute-care setting for management of acute respiratory failure. The European Respiratory Society and American Thoracic Society selected 11 questions relating to application of NIV for various etiologies of ARF and developed corresponding recommendations. Strong recommendations were made in favor using NIV for patients with ARF leading to acute respiratory acidosis due to COPD exacerbation, as well as the use of either NIV or CPAP for patients with ARF due to cardiogenic pulmonary edema. Conditional recommendations were made against the use of NIV in those patients with hypercapnia who are not acidotic, as well as in non-high-risk patients to prevent respiratory failure post-extubation or in patients with established post-extubation respiratory failure.

Critical outcomes were mortality, the need for intubation and the incidence of nosocomial pneumonia. For the purposes of these guidelines, NIV includes the noninvasive delivery of variable positive airway pressure by means of bilevel devices, as well as continuous positive airway pressure (CPAP) using a nasal, oronasal or facial interface. This article covers nine of the 11 questions contained in the guidelines.

Question 1: Should NIV be used in COPD exacerbation? Exacerbations of chronic obstructive pulmonary disease (COPD) are a frequent cause of hospital admission. Many of these COPD patients may develop respiratory acidosis due to inadequate alveolar ventilation despite a high level of diaphragmatic activity. The committee considered three relevant clinical settings and split the question into two parts.

Question 1a: Should NIV be used in ARF due to a COPD exacerbation to prevent the development of respiratory acidosis? The majority of the evidence comparing bilevel NIV with standard oxygen therapy showed no advantage for NIV, with no effect on either the mortality or the intubation rate. Based on the inconsistent evidence, the committee suggested not using NIV in those patients with hypercapnia who are not acidotic, and noted
that the delivery of oxygen targeted to reach a saturation of 88%-92% may be of more benefit.

**Question 1b: Should NIV be used in established hypercapnic respiratory failure due to a COPD exacerbation?** This answer was two-fold. In patients with a pH of 7.25-7.35, the evidence shows that bilevel NIV reduces the need for immediate intubation and improves survival, with no worse outcomes when compared with standard nonventilatory management. Studies comparing NIV directly with invasive ventilation showed similar mortality rates, but also showed advantages in terms of duration of ICU and hospital stay, as well as fewer complications including ventilator-associated pneumonia and the need for tracheostomy. In all cases of COPD exacerbation, bilevel NIV has been shown to be a cost-effective form of therapy. With pooled evidence showing a positive effect of all three critical outcomes, the committee recommends the use of NIV for patients with ARF leading to acute respiratory acidosis due to COPD exacerbation, in particular when the pH is \( \leq 7.35 \), PaCO2 is > 45 mmHg and the respiratory rate is > 20-24 breaths per minute. The committee also recommends trialing bilevel NIV in patients considered to require intubation and mechanical ventilation; however, the risk of failure increases with a lower pH and patients should be monitored closely.

**Question 2a: Should NIV be used in ARF due to cardiogenic pulmonary edema?** In such cases, NIV (both bilevel and CPAP) may have a positive effect by increasing respiratory system compliance and facilitating left ventricular work to relieve the high capillary pressure that causes alveolar flooding. Based on trials comparing the use of CPAP and/or NIV with standard therapy or each other, which showed that both NIV and CPAP decrease the need for intubation and are associated with a reduction in hospital mortality, the committee recommends the use of either NIV or CPAP for patients with ARF due to cardiogenic pulmonary edema. However, this recommendation does not extend to patients in cardiogenic shock.

**Question 2b: Should a trial of CPAP prior to hospitalization be used to prevent deterioration in patients with ARF due to cardiogenic pulmonary edema?** A pooled analysis of results from six single-centre randomized controlled trials (RCTs) showed that NIV decreased mortality and the need for intubation; in addition, oxygenation and dyspnea scores were shown to improve faster with CPAP or bilevel NIV than in the control group. However, due to the differences in trial design, personnel and patient selection, the certainty of evidence was low and the recommendation for use CPAP or bilevel NIV in this setting is conditional only. The committee emphasized the need for correctly trained staff and suitable infrastructure.

**Question 4: Should NIV be used for ARF in immunocompromised patients?** Although several studies have demonstrated benefits of NIV in these patients and a pooled analysis of all evidence demonstrated a decrease in the three relevant outcomes, a recent randomized
trial and post hoc analysis of sub-group showed no effect on survival. The committee therefore made a conditional recommendation for use of both bilevel NIV and CPAP for immunocompromised patients, while also noting that a recent RCT found benefits of high flow nasal cannula oxygen therapy over bilevel NIV and this comparison therefore requires further investigation.

**Question 5: Should NIV be used in de novo ARF?** Respiratory failure occurring in patients with no prior chronic respiratory disease is usually hypoxemic respiratory failure, which combines significant hypoxemia, tachypnea and pneumonia and/or acute respiratory distress syndrome (ARDS). In these patients, NIV is intended to improve oxygenation and facilitate ventilation, as well as decrease the work of breathing and avoid intubation. However, there are several limitations when using NIV, including the excessive pressure required to inflate the lungs and the inability to maintain low tidal volumes, the risk associated with interruptions to NIV (immediate return of hypoxemia and work of breathing) and the effect of the type of interface on the tolerance and duration. While the pooled analysis did in fact show a decrease in mortality and the need for intubation, it seems that this is heavily dependent on patient selection and the experience of the clinician. The uncertainty of the evidence and the specific risks associated with the use of NIV, such as the delay of necessary intubation in certain patients, resulted in the committee offering no recommendation for using NIV for de novo ARF. Although the recommendation did not address the use of high flow nasal cannula therapy, the committee noted that it may assume greater significance in the future treatment of de novo respiratory failure. While much of the earlier evidence focused on a comparison of NIV with standard oxygen therapy, recent evidence has shown high flow nasal cannula therapy to have several advantages over NIV, including improved tolerance and dead space reduction.

**Question 6: Should NIV be used in ARF in the post-operative setting?** Evidence has shown that NIV and CPAP may improve the deleterious effects on the respiratory system caused by surgery, anesthesia and post-operative pain. Both forms of therapy may increase lung aeration and arterial oxygenation, and decrease the amount of atelectasis with no adverse hemodynamic effects. Studies indicate that NIV may decrease mortality, the occurrence of nosocomial infections and the need for reintubation in patients having undergone abdominal or thoracic surgery, as well as reducing the length of stay and morbidity. However, based on the low certainty of the evidence for two outcomes, the recommendation for use of NIV in the post-operative setting was conditional only. The committee also noted the importance of attending to surgical complications such as intra-abdominal sepsis before initiating NIV.

**Question 7: Should NIV be used in patients with ARF receiving palliative care?** For this question only, the panel prioritized the critical outcome as patient-reported dyspnea. As death approaches, dyspnea may intensify and relief from breathlessness to ensure greater comfort is a primary consideration. One RCT investigated the efficacy of NIV in reducing
dyspnea found a similar improvement in dyspnea for both NIV and high-flow oxygen, while a second trial showed a significant reduction in breathlessness with NIV. Patient acceptance was similar for both treatments. The pooled analysis of data showed that NIV improves dyspnea and may also reduce the need for morphine; however, results in terms of respiratory rate and oxygenation were less clear. The committee also noted the importance of patient selection and adequate training in facilities where NIV is not standard practice. For those patients with terminal conditions where NIV is a life support, or for those only requiring symptom alleviation, the committee made a conditional recommendation for the use of NIV in the palliative-care setting. Due to the lack of RCT evidence, the recommendation did not extend to those patients who have decided against intubation, but still have the goal of surviving hospitalization. However, in the relevant observational studies, the use of NIV was associated with a hospital survival rate of > 30-60%.

**Question 8: Should NIV be used in ARF due to chest trauma?** A small number of RCTs have compared the use of NIV or CPAP with either supplemental oxygen or invasive mechanical ventilation in these patients. The pooled analysis showed that NIV had a positive effect in terms of critical outcomes, particularly mortality and the need for intubation) as well as decreasing the length of ICU stay. Despite these positive results overall, the small number of studies and the differences in trial design, comparators, severities of patients at enrollment and causes of ARF led to the committee making a conditional recommendation for use of NIV in ARF due to chest trauma. In patients with controlled pain and without severe hypoxemia, NIV may be trialed with caution.

**Question 10a: Should NIV be used to prevent respiratory failure post-extubation?** Studies have investigated the use of NIV soon after extubation in both unselected and at-risk patients. In unselected patients, NIV showed neither better outcomes nor any benefit over standard treatment. For at-risk patients, NIV was shown to lower the rate of respiratory failure post-extubation, while the impact of NIV on critical outcomes differed between various studies. Interestingly, one study demonstrated a significantly higher 90-day survival rate in the NIV group. Overall, the decrease in mortality and need for intubation was sufficient to justify a conditional recommendation for use of NIV soon after planned extubation in high-risk patients. The recommendation did not extend to patients with an unplanned extubation, who were considered to be a different risk group. For non-high-risk patients, the committee made the conditional recommendation against use of NIV.

**Question 10b: Should NIV be used in the treatment of respiratory failure that develops post-extubation?** Two studies comparing NIV with conventional treatment (oxygen therapy) for patients developing respiratory failure after planned extubation showed no benefit in terms of the clinical outcomes, with an uncertain effect on intubation rates and one trial showing higher ICU mortality with NIV than for conventional treatment, possibly due to delayed intubation. The committee therefore suggested that NIV should not be used for patients with established post-extubation respiratory failure, however noted that this may
not apply to post-extubation COPD patients (due to low numbers of such patients in the relevant studies).

**Question 11: Should NIV be used to facilitate weaning patients from invasive mechanical ventilation?** In 16 RCTs enrolling primarily COPD patients, NIV was compared with conventional weaning (gradual decrease of inspiratory support or SBTs) and was shown to significantly reduce mortality, the proportion of weaning failures, the duration of hospital and ICU stay, the incidence of VAP and the total duration of mechanical ventilation. In the largest trial comparing conventional weaning with early extubation followed by NIV or oxygen therapy, the rates of re-intubation were similar, but the patients randomized to the NIV group showed significantly better cumulative rates of weaning success. Due to the difficulties related to the use of NIV for weaning (compared with other indications), the committee made a conditional recommendation for use of NIV to facilitate weaning in patients with hypercapnic respiratory failure. However, the recommendation does not extend to hypoxemic patients and the committee also noted the need for sufficient experience in this setting.

In conclusion, the committee stressed that the implementation of the guidelines must always be based on the features of the individual patient and clinical judgement in each individual case. The committee also noted that future changes to these recommendations are anticipated as more evidence becomes available in relation to newer technologies such as high-flow nasal cannula therapy and extracorporeal CO2 removal.

All Hamilton Medical ventilators offer noninvasive ventilation modes that deliver pressure-supported, flow-cycled spontaneous breaths (NIV and NIV-ST mode) and pressure-controlled, time-cycled mandatory breaths (NIV-ST mode). In NIV modes, the ventilator functions as a demand flow system. When pressure support in NIV mode is set to zero, the ventilator functions like a conventional CPAP system. The IntelliTrig leak compensation function adapts to changing breath patterns and airway leaks to achieve optimum synchronization between patient and device.

In addition, high flow oxygen therapy* is available as a standard or optional feature on almost all Hamilton Medical ventilators. In just a few steps, you can change the interface and use the same device and breathing circuit to accommodate your patient’s needs.

* Not available in all markets.

**References**
