



Noninvasive positive pressure ventilation in acute respiratory failure: Does it improve outcomes?

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■ ABSTRACT

Studies have shown that noninvasive positive pressure ventilation (NPPV) is well tolerated and safe, and that it improves oxygenation in some patients with acute respiratory failure. By obviating the need for endotracheal intubation in certain conditions, it results in fewer complications, shorter hospital stays, and consequently, lower mortality rates and costs of care.

WHY INSERT an endotracheal tube when a mask may do? For many patients with acute respiratory failure, noninvasive positive pressure ventilation (NPPV), in which a mask or mouthpiece is used, can give the benefits of standard endotracheal ventilation without subjecting the patient to intubation, with its attendant complications.

Interest in NPPV has grown since 1987, when several reports¹⁻³ found that it relieved symptoms and improved gas exchange in patients with chronic respiratory failure. Since then, it has been successfully used in many patients with acute respiratory failure as well, and its use has increased dramatically in the last 5 years. At the Cleveland Clinic, the number of patient-days on NPPV increased to approximately 1,600 in the year 2000, nearly four times as many as in 1995.

Because NPPV avoids some of the complications of intubation (pneumonia, sinusitis, and trauma to the airway), NPPV patients incur shorter hospital stays, lower mortality rates, and lower healthcare costs. Another advantage is that it is more comfortable for

the patient, who retains the ability to speak, swallow, and protect the upper airway.

This discussion focuses on use of NPPV in the intensive care unit and in the care of patients with acute respiratory failure due to severe exacerbations of chronic obstructive pulmonary disease (COPD), cardiogenic pulmonary edema, and acute hypoxemic nonhypercarnic respiratory failure, including severe pneumonia or acute respiratory distress syndrome (ARDS).

■ TYPES OF NPPV

There are three commonly used ways of delivering NPPV:

- **Continuous positive airway pressure (CPAP)**, in which the machine delivers air at a constant positive pressure during inspiration and expiration
- **Volume-cycled, flow-limited**, in which the machine delivers a set tidal volume each time the patient begins to take a breath
- **Pressure-limited**, which in turn can be of three types:

Pressure support, in which the machine delivers air at a set pressure during inspiration every time the patient starts to take a breath

Pressure control, in which the machine automatically delivers a set number of breaths per minute at a set pressure

Bilevel positive airway pressure (BiPAP), in which the machine delivers different pressures during inspiration and expiration.

What type is best?

Pressure support and BiPAP are the most common types of NPPV used today, but stud-

NPPV is more comfortable and allows the patient to speak, swallow, and cough

ies to gauge which is best have been inconclusive.⁴ Because all the types appear to be similarly efficient, the choice should be made on the basis of local expertise and tailored to the cause and severity of the patient's respiratory failure.⁴ The settings should be adjusted to provide the lowest inspiratory pressures or volume to make it as comfortable as possible for the patient while maintaining adequate oxygenation.

What type of mask?

NPPV is given through a full-face mask, a nasal mask, nasal "pillows," or a mouthpiece. There has been some debate about which type of interface (ie, mask or mouthpiece) is most effective. There is no significant difference between types of masks.⁴

Ultimately, the best type of mask is the one with which the respiratory therapist and the patient feel most comfortable; several masks should be available for the patient to try. It is crucial that the mask be tight enough to avoid leakage but not so tight that the patient becomes agitated or the nasal bridge becomes ulcerated. Mouthpieces are more often used in patients with chronic respiratory failure, such as those with amyotrophic lateral sclerosis.

■ WHERE SHOULD NPPV BE GIVEN?

Ideally, NPPV should be started in an intensive care unit, but it can be started in other types of nursing units, provided they have good monitoring capacity. Any patient whose dyspnea does not improve or who experiences deterioration of mental status or hemodynamic derangement should be transported to an intensive care unit. Patients on NPPV need to be monitored carefully because those who do not improve within a short time of starting therapy are at high risk for cardiac complications such as arrhythmias and even cardiac arrest during intubation.

■ CAUTIONS, COMPLICATIONS

Not all patients are suitable candidates for NPPV. The patient must be alert and have a patent upper airway for ventilation and secretion removal. NPPV should be stopped or not

used at all in patients with cardiac or respiratory arrest, severe encephalopathy, gastrointestinal bleeding, hemodynamic instability (ie, a drop in systolic blood pressure to below 90 mm Hg), unstable arrhythmia, abnormalities of the face, trauma or deformity, agitation that requires sedation, upper airway obstructions, inability to clear secretions, or a high risk of aspiration.⁴

In addition, edentulous patients or those with beards are likely to have large mouth leaks that may hinder administration of ventilation.⁵

Complications of NPPV include nasal bridge ulceration, nasal congestion, eye irritation, gastric distention, and aspiration.⁶ Gastric distention can be alleviated by using a nasogastric tube. Aspiration can be prevented by using NPPV only in patients who are awake and alert.

■ EFFICACY OF NPPV

NPPV appears to be most valuable in patients with exacerbations of COPD, although some success has been achieved in patients with cardiogenic pulmonary edema. Results in patients with acute hypoxemic nonhypercapnic respiratory failure have not been as encouraging.

Use of NPPV in COPD

Prospective randomized trials have demonstrated that 50% to 70% of patients who have severe exacerbations of COPD and who receive NPPV can avoid being intubated.⁷ Furthermore, the reduction in the need for intubation results in a reduction in the mortality rate. In addition, NPPV translates into shorter hospital stays and decreased costs of care.⁸

Survival is higher than without ventilation. Recently, Plant et al⁹ conducted a randomized controlled study in 236 patients with exacerbations of COPD to compare outcomes of NPPV (BiPAP) with those of standard therapy (which included oxygen by face mask or nasal cannula, prednisolone, bronchodilators, and antibiotics). Eighteen (15.3%) of the 118 patients receiving NPPV ultimately required intubation, compared with 32 (27%) of the 118 patients receiving standard therapy ($P =$

Consider NPPV only if the patient is alert and awake



.02). Moreover, fewer patients died who received NPPV: 12 (10%) vs 24 (20%) ($P = .05$).

Keenan et al⁸ conducted a meta-analysis and calculated the odds ratio of hospital mortality at 0.22 (95% confidence interval 0.10–0.66) for patients with severe exacerbations of COPD receiving NPPV compared with standard therapy. They also calculated that \$3,244 (Canadian) would be saved per patient admission if NPPV were used instead of standard therapy.

Response can be assessed in the first hour. It is important to predict which patients are likely to respond to NPPV. In general, those who do best have normal mental status and are alert and able to accept the face mask.

Antón et al¹⁰ examined the records from 49 patients who received NPPV (BiPAP in spontaneous mode) to treat 59 episodes of acute respiratory failure. NPPV was successful (ie, the patient avoided being intubated) in 46 (77%) of the episodes. Using logistic regression analysis, the investigators found several factors that predicted success with NPPV:

- Higher level of consciousness on admission
- Lower FEV₁ on admission
- Significant improvements in pH, PaCO₂ and level of consciousness after 1 hour of NPPV. In patients in whom NPPV succeeded, the pH rose from a mean of 7.27 to 7.34, and the PaCO₂ decreased from 81 to 68 mm Hg. In contrast, these measures did not change in patients in whom NPPV failed.

Staffing time only slightly increased. The time required for a nurse or respiratory therapist to spend with patients receiving NPPV is not significantly greater than that required for standard therapy. Plant et al⁹ estimated that in the first 8 hours of treatment, nurses and respiratory therapists spent about 24 more minutes with patients receiving NPPV.

Survival may be higher than with invasive ventilation. A study by Vitacca et al¹¹ suggested that COPD patients who receive NPPV have a lower mortality rate than patients treated with invasive mechanical ventilation: 20% vs 26% in the intensive care

unit, 23% vs 48% at 3 months, and 30% vs 63% at 1 year. These findings must be interpreted with caution because the study was retrospective and it was not clear whether the patients who received NPPV were less ill or whether patients remained on NPPV following hospital discharge.

NPPV in cardiogenic pulmonary edema

NPPV has had somewhat less encouraging results in patients with cardiogenic pulmonary edema: it does not result in significantly improved outcomes, but it does improve oxygenation faster and reduce the need for intubation. At least two randomized controlled trials^{12,13} showed that CPAP improved vital signs and oxygenation and reduced the need for intubation. However, one study¹⁴ raised some concern when it showed that patients who received CPAP experienced more myocardial infarctions than those treated with pressure support (71% vs 31%).

Masip et al,¹⁵ in a recent prospective controlled randomized trial, compared the need for intubation and recovery time with NPPV vs conventional oxygen therapy. In the first half hour of treatment, patients receiving pressure support ventilation had better oxygenation; however, there was no significant difference in oxygenation between the two groups at 4 hours. Duration of hospital stay and the mortality rate were similar in both groups. However, six (33%) of the patients in the control group required intubation, compared with only one (5%) of the patients receiving NPPV. Patients who required intubation after receiving NPPV tended to have more radiographic evidence of cardiogenic pulmonary edema, a higher previous New York Heart Association score, and a higher PaCO₂ (53 vs 44 mm Hg).

NPPV in acute hypoxemic nonhypercapnic respiratory failure

NPPV has been of limited use in the treatment of patients with acute hypoxemic nonhypercapnic respiratory failure, who in general do not have a history of COPD, are very hypoxic, and have bilateral infiltrates.⁴

There has been some controversy about the indications for NPPV in these patients.

Wysocki et al,¹⁶ in a study of patients with

It is important to predict which patients are likely to respond to NPPV



acute hypoxemic nonhypercapnic respiratory failure (most had pneumonia or cardiogenic pulmonary edema) found no improvement in patients treated noninvasively over those treated by conventional methods. However, they found that the rates of intubation and mortality were less and the length of hospital stay was shorter in patients with a higher PaCO₂ who received NPPV than in those with a low PaCO₂. Although the study was too small to yield clinically useful results, it did suggest that patients with a higher PaCO₂ may derive the most benefit from NPPV.

Confalonieri et al,¹⁷ in a multicenter prospective randomized trial, compared the efficacy of pressure support vs standard therapy in patients with severe community-acquired pneumonia who were in respiratory failure. NPPV was found to decrease the need for intubation and the length of stay in an intensive care unit.

Antonelli et al¹⁸ performed a similar study, comparing the use of pressure support vs standard therapy. They found that the noninvasive method improved oxygenation and was

as effective as conventional therapy in improving the ratio of PaO₂ to FiO₂. The ratio in the patients receiving noninvasive therapy was 116 and improved to 230; in patients receiving invasive therapy, 124 and 211. The rates of pneumonia and sinusitis were decreased in the group treated with NPPV.

In another multicenter prospective randomized trial,⁶ Delclaux et al compared the use of CPAP with use of oxygen alone. They found that at 1 hour patients treated with CPAP had better oxygenation, less dyspnea, decreased respiratory rate, and some improvement in pH. However, the differences between the two groups were no longer evident after an hour. In addition, there were no differences between the two groups in intubation requirements, length of stay in an intensive care unit, or mortality rate. Adverse events were more common with CPAP than with use of oxygen alone, occurring in 14 (23%) of the CPAP group vs 5 (8%) of the oxygen group (*P* = .03). Four patients on CPAP experienced cardiac arrest vs 0 in the oxygen group.

REFERENCES

- Kerby GR, Mayer LS, Pingleton SK. Nocturnal positive pressure ventilation via nasal mask. *Am Rev Respir Dis* 1987; 135:738-740.
- Bach JR, Alba A, Mosher R, Delaubier A. Intermittent positive pressure ventilation via nasal access in the management of respiratory insufficiency. *Chest* 1987; 92:168-170.
- Ellis ER, Bye PT, Bruderer JW, Sullivan CE. Treatment of respiratory failure during sleep in patients with neuromuscular disease: positive-pressure ventilation through a nose mask. *Am Rev Respir Dis* 1987; 135:148-152.
- International consensus conferences in intensive care medicine. Noninvasive positive pressure ventilation in acute respiratory failure. American Thoracic Society, European Respiratory Society, European Society of Intensive Care Medicine, Société de Réanimation de Langue Française. *Am J Respir Crit Care Med* 2001; 163:283-291.
- Ambrosino N, Foglio K, Rubini F, Clini E, Nava S, Vitacca M. Non-invasive mechanical ventilation in acute respiratory failure due to chronic obstructive pulmonary disease: correlates for success. *Thorax* 1995; 50:755-757.
- Delclaux C, L'Her E, Alberti C, Mancebo J, Abroug F, Conti G. Treatment of acute hypoxemic nonhypercapnic respiratory insufficiency with continuous positive airway pressure delivered by a face mask: a randomized controlled trial. *JAMA* 2000; 284:2352-2360.
- Consensus Conference. Noninvasive positive pressure ventilation. *Respir Care* 1997; 42:364-369.
- Keenan SP, Gregor J, Sibbald WJ, Cook D, Gafni A. Noninvasive positive pressure ventilation in the setting of severe, acute exacerbations of chronic obstructive pulmonary disease: more effective and less expensive. *Crit Care Med* 2000; 28:2094-2102.
- Plant PK, Owen JL, Elliott MW. Early use of non-invasive ventilation for acute exacerbations of chronic obstructive pulmonary disease on general respiratory wards: a multicentre randomised controlled trial. *Lancet* 2000; 355:1931-1935.
- Antón A, Güell R, Gómez J, et al. Predicting the result of noninvasive ventilation in severe acute exacerbations of patients with chronic airflow limitation. *Chest* 2000; 117:828-833.
- Vitacca M, Clini E, Rubini F, Nava S, Foglio K, Ambrosino N. Non-invasive mechanical ventilation in severe chronic obstructive lung disease and acute respiratory failure: short- and long-term prognosis. *Intensive Care Med* 1996; 22:94-100.
- Räsänen J, Heikkilä J, Downs J, Nikki P, Väisänen I, Viitanen A. Continuous positive airway pressure by face mask in acute cardiogenic pulmonary edema. *Am J Cardiol* 1985; 55:296-300.
- Bersten AD, Holt AW, Vedig AE, Skowronski GA, Baggoley CJ. Treatment of severe cardiogenic pulmonary edema with continuous positive airway pressure delivered by face mask. *N Engl J Med* 1991; 325:1825-1830.
- 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; 25:620-628.
- Masip J, Betbese AJ, Paez J, et al. Non-invasive pressure support ventilation versus conventional oxygen therapy in acute cardiogenic pulmonary oedema: a randomised trial. *Lancet* 2000; 356:2126-2132.
- Wysocki M, Tric L, Wolff MA, Millet H, Herman B. Noninvasive pressure support ventilation in patients with acute respiratory failure. A randomized comparison with conventional therapy. *Chest* 1995; 107:761-768.
- 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; 160:1585-1591.
- Antonelli M, Conti G, Rocco M, et al. A comparison of noninvasive positive-pressure ventilation and conventional mechanical ventilation in patients with acute respiratory failure. *N Engl J Med* 1998; 339:429-435.

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