Noninvasive Positive Pressure Ventilation Requires Healthcare Team Spirit

CE475 :: 1.00 Hours

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Objectives

The goal of this continuing education program is to provide acute and critical care clinicians with evidence supporting the use of noninvasive positive pressure ventilation (NPPV) as well as strategies for its application. After studying the information presented here, you will be able to —

- Describe the advantages of NPPV vs. endotracheal intubation.
- State the difference between bilevel support and continuous positive airway pressure (CPAP).
- Discuss alternative interface devices and related care for patients requiring NPPV.

Entering a sports season, tryouts and practices begin, and coaches make decisions based on the team’s ability, skill and synergy. Once the season starts, team members must coordinate their efforts to achieve victory. While teams may have a star, they cannot achieve victory without the participation of all team members.

Successful noninvasive positive pressure ventilation requires the same level of team support and competence. To that end, the caregiver with a good understanding of NPPV is well positioned to work with a team of respiratory therapists, physicians, nurse practitioners and discharge planners. An organized, patient-focused plan of care fosters effective outcomes and improves the quality of patient care.

Noninvasive positive pressure ventilation is the delivery of mechanical ventilation to the lungs using techniques that do not require an endotracheal tube. In the first half of the 20th century, negative pressure noninvasive ventilation, known as an iron lung, was used to treat respiratory failure. In the 1950s, intermittent positive pressure breathing was used to deliver nebulizers to hospitalized patients. NPPV was developed from intermittent positive pressure breathing. Initially, NPPV was used at night, for patients with neuromuscular disease. An interface device is the connection used to deliver ventilatory support to the patient from the machine. In the 1960s, invasive positive pressure ventilation became the treatment of choice because of the airway protection it offered. During the 1990s, interest in noninvasive ventilation reemerged with the advent of nasal ventilation. Nasal ventilation was convenient, safe, comfortable and cost-effective.¹² (Level A)

NPPV treats respiratory failure and obstructive sleep apnea (OSA). The short-term goals of NPPV are to relieve symptoms, decrease work of breathing, improve gas exchange, increase comfort, decrease risk of injury and avoid endotracheal intubation. The long-term goals include improvement of sleep, quality of life and function (ADLs).¹

By supporting ventilation through an interface device in NPPV use, the patient may be spared...
complications. For example, endotracheal intubation carries the risk of ventilator-associated pneumonia and trauma to the teeth, esophagus and larynx.

Postextubation complications include hoarseness, sore throat, cough, sputum production, hemoptysis, upper airway obstruction, tracheal stenosis (narrowing and hardening of the trachea) and vocal cord dysfunction. Tracheal cannulation carries the risk of bleeding, infection, intubation of a false lumen and acute tracheal injury.³ (Level A)

**Recommended Uses**

Studies show NPPV is an effective treatment for respiratory failure related to congestive heart failure by preventing the progression of respiratory failure or preventing hemodynamic instability and intubation. The risk of myocardial infarction is not increased when NPPV is used vs. continuous positive airway pressure (CPAP). According to clinical trials, NPPV reduces the need for intubation and reduces mortality in patients with acute cardiogenic pulmonary edema. NPPV reduces mortality, overall length of stay and the need for invasive mechanical ventilation.³ (Level A)

Research supports the use of NPPV in critical situations of hypercapnic (excessive carbon dioxide in the blood), respiratory failure relative to COPD and acute cardiogenic pulmonary edema. However, it does not support NPPV for patients who have failed endotracheal extubation. NPPV used in the treatment of COPD and acute pulmonary edema, and with immunocompromised patients reduces mortality rates and the need for intubation.⁴ (Level A)

The American Association for Respiratory Care endorses early use of NPPV when at least two of the following criteria exist in the absence of contraindications in patients with COPD: respiratory distress with moderate dyspnea; arterial pH less than 7.35; pCO₂ greater than 45 mmHg; respiratory acidosis; and a respiratory rate of more than 25 breaths per minute. It’s unclear whether NPPV has an effect on long-term outcomes; however, there’s no significant change in survival outcomes. Studies show the use of NPPV yields fewer hospital admissions in a year.⁵

### Indications for NPPV

#### Obstructive

- COPD exacerbation
- Asthma
- Cystic fibrosis
- Pulmonary edema
- Hypoxemic respiratory failure (e.g., pneumonia, acute respiratory distress syndrome, trauma, compromised immune function)
- Postoperatively
- Facilitation of weaning postextubation
- “Do not intubate” advance directive

#### Restrictive

- Chest wall deformity
- Obesity hypoventilation
- Neuromuscular diseases
- Polio
- Diaphragm paralysis
- High spinal cord injury
- Amyotrophic lateral sclerosis
- Duchenne’s muscular dystrophy
Guillain-Barré syndrome
Myasthenia gravis

Predictors of Success for NPPV

- Younger age
- Lower illness acuity
- Ability of patient to cooperate
- Ability to coordinate breathing with ventilator
- Decreased air leak
- Intact dentition
- Hypercarbia (greater than 45 mmHg and less than 92 mmHg)
- Acidemia (less than 7.35 and greater than 7.0)
- Improvement in gas exchange, heart rate, and respiratory rate in the first hour of therapy

Mechanical Ventilation Modes

Clinicians should be familiar with the mechanical ventilation modes for NPPV delivery. CPAP is equivalent to positive end expiratory pressure (PEEP) with endotracheal intubation or a tracheotomy and mechanical ventilation. CPAP is not a true ventilator mode since it does not actively support inspiration. It improves gas exchange by preventing alveolar collapse at end expiration and decreases the work of breathing. It delivers constant pressure during inspiration and expiration. The possible range of pressure used is 5 cmH2O to 12 cmH2O, although higher pressures may be used in certain circumstances as dictated by patient need and tolerance. CPAP therapy can reduce hypopnea (abnormally shallow breathing), decrease daytime sleepiness, and improve sleep and quality of life. The average patient use of CPAP in multiple studies is five hours per night. About half of patients with OSA use the therapy at night as directed.

The term BiPAP, bilevel positive airway pressure, is used interchangeably with bilevel ventilation. Bilevel ventilation, an alternative treatment to intubation, can improve oxygenation and decrease left ventricular afterload and atelectasis. BiPAP provides a volume of pressure with inspiratory effort. This is known as inspiratory peak airway pressure, or IPAP, which provides muscle rest. Positive pressure delivered in the expiratory phase is also known as expiratory peak airway pressure, or EPAP.

Complications and Contraindications

Positive pressure delivered from NPPV can cause gastric distention and vomiting, which increases the risk of aspiration because the patient is unable to protect his or her airway. Other adverse effects include nasal congestion, nasal and oral drying, and eye irritation. Barotrauma (damage to body tissues caused by a difference in pressure between an air space inside or beside the body and the surrounding gas or liquid), due to increased pressure delivery, is a possible adverse effect of pneumothorax (collapsed lung). Positive pressure from NPPV can cause barotrauma and possible pneumothorax. At the site of the interface device, skin can break down on the face and bridge of the nose.

An absolute contraindication of NPPV is the emergent need for intubation. Other contraindications include respiratory arrest, secretions that are not controlled, nausea with emesis and restlessness that prohibits interface device compliance. Facial trauma or a patient’s inability to cooperate decreases the success of NPPV. For home use, noncompliance, poor motivation, or the lack of a support system at home or financial resources will likely diminish success.
Delivery Devices

Many devices are available for the delivery of NPPV. In the acute care environment, higher technology units can deliver both CPAP and bilevel ventilation. These units have a range of settings that include precise oxygen delivery, tidal volume monitoring and backup respiratory rates in the event of apnea. Some devices allow the user to adjust delivery with rise time settings and flow. Autotitrating units respond to a patient's need and deliver the pressure accordingly. Bilevel devices found in the critical care setting have more sophisticated synchrony. Some devices offer ventilator support with both the interface device and intubation.

Other devices are specific to one type of mode and have fewer monitoring tools. Flow rates vary with devices, and the patient may feel more comfortable on one model than another. Portable bilevel devices are used for discharge planning and transport. Respiratory therapists often take the lead in selecting the appropriate device.

When a person who uses NPPV at home is hospitalized, the biomedical engineering department examines the machine’s functioning, and the care team evaluates the patient's response to the home machine in the hospital. Setting adjustments may be needed. The home care supplier may be able to help with changes in settings or interfaces.

Home care devices have quieter operation and have fewer monitoring tools and are mode-specific. The mode can be selected and locked in to avoid user error or interference with settings.

Protocols

Patients requiring NPPV may need more clinician attention, thus raising the level of care acuity. However, study results are conflicting. Some studies indicate that patients starting NPPV require more nursing care. Other studies indicate that nurses spend no additional time at the bedside of NPPV patients. Interestingly, RTs spend the most time at the bedside in the first eight hours of therapy for patients requiring NPPV.¹

Patients requiring NPPV are triaged according to an institution’s protocol and caregivers’ competence in managing NPPV. Outcomes improve as caregivers gain experience with NPPV application. The ICU may be the best venue for NPPV, but if resources are available, NPPV can be successful in the ED, step-down unit or general care floor depending on a hospital’s protocols. Research shows that success in avoiding intubation depends on patient selection and clinicians’ familiarity with NPPV. When NPPV use is planned (vs. emergency use) and disease selection is appropriate for the NPPV application, NPPV should improve outcomes and provide the more efficient use of resources.

Starting a bilevel device with low initial pressures may help the patient’s initial tolerance. The IPAP may range from 8 cmH₂O to 14 cmH₂O, and the EPAP can range from 4 cmH₂O to 5 cmH₂O and provides pressure support of 4 cmH₂O to 10 cmH₂O. Target volumes of 8 mL/kg to 15 mL/kg may be reasonable. Depending on the patient’s tolerance and response to therapy, pressures may be titrated upward to provide increased tidal volumes as therapy continues. To evaluate effectiveness of bilevel device use, an arterial blood gas sample can be obtained at the end of titration or in the morning after a night of therapy.³,⁶

Interface Devices

The interface device is the part of the apparatus that delivers airway support to the patient. The interface device attaches to the tubing from the patient to the machine. The full-face oronasal mask covers the nose and mouth. The edges of the mask, which create the seal, have a soft cushion. The cushion may have a gel material inside to provide comfort and alleviate pressure on the skin. Elastic headgear with fasteners positions the interface device on the patient’s head. Custom masks can be used for patients who wear glasses.

<table>
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<th>Interface Devices</th>
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In the ED, the primary goals for the patient with respiratory distress are to support respiratory function and prevent respiratory failure. The oronasal mask is often the first choice for emergency ventilation. Device setup and readiness are crucial for the success of NPPV. Collaboration between the nurse and RT ensures that the patient and family understand the therapy and its purpose.

The size of the patient’s face determines the size of the interface device. The interface device and headgear are best applied after oral care and skin preparation. Allowing the patient to hold the mask in place first may help alleviate anxiety. Replacing an uncomfortable interface device with a more comfortable one may be an option as long as the seal is intact, there is minimal air escaping into the patient’s eyes and the patient is comfortable.

The use of NPPV may be a less urgent matter in a step-down unit or general care floor than in the ICU. The nurse and RT may be able to try different interface devices to acclimate the patient to the therapy. The patient’s tolerance of the mask and therapy is evaluated, and adjustments are made.

Whenever the interface device is removed, the skin is assessed. Any signs of pressure or redness should be noted. A hydrocolloid dressing on pressure points may help with skin integrity. The headgear strap may need adjustment to distribute pressure on the face and nose. Oral care and oral intake while the interface device is off will help prevent hospital-acquired pneumonia as decreasing oral bacteria reduces the risk of aspiration. No oral intake is safe while the patient is on an interface device because of the risk of aspiration with continued pressure delivery. Lip moisturizers can help with dryness and discomfort. Interface devices wear out, so nurses and RTs should inspect the device for wear and leakage and replace as necessary.3,6

**Advance Directives**

Clinicians should educate patients about NPPV in relationship to their advance directives. NPPV is

<table>
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<tr>
<th>Full-face Oronasal</th>
<th>Good seal</th>
<th>Claustrophobic feeling</th>
<th>High risk for aspiration</th>
<th>Interference with speech</th>
<th>Mouth breathers</th>
<th>First-line for emergency application</th>
</tr>
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<tbody>
<tr>
<td>Nasal mask</td>
<td>Comfort</td>
<td>Air loss if the patient breathes through the mouth.</td>
<td>Choice for long-term use</td>
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<tr>
<td>Nasal pillows</td>
<td>Low profile</td>
<td>Pressure directly on nares may be uncomfortable</td>
<td>Air loss if the patient breathes through the mouth.</td>
<td>Choice for long-term use</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full-face shield Total face mask</td>
<td>Good seal</td>
<td>Entire face is encased.</td>
<td>Alternative for patients who have poor fit with other devices.</td>
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considered life support in some situations. For a patient with a DNR order, continued NPPV support can raise significant ethical issues, as it’s a life-supporting intervention. Providers have a responsibility to explain the NPPV option to patients and families. They also need to explain the use of NPPV as a temporary vs. a long-term solution to the underlying problem or disease.

**Assessment and Plan of Care**

Patients need time off from NPPV for adequate nutritional intake. Backup oxygen therapy during meals and assistance with meals may decrease dyspnea and promote adequate intake. Patients can usually tolerate small, frequent high-protein meals. Although an RT may apply and remove NPPV, nurses and registered dietitians need to collaborate to ensure good nutrition.

Small-bore feeding tubes provide the best alternative nutrition option. The small tube decreases the risk of aspiration. Large-bore nasogastric tubes may present a higher risk for vomiting leading to aspiration. Feeding options should be considered on an individual basis.³

Compliance is directly related to comfort. Humidification with a pass-by system can help increase patient comfort. NPPV delivers air with low relative humidity and high inspiratory pressures; humidification increases the moisture of the air delivered.⁷ (Level B) Saline nasal spray in addition to system humidification can help with nasal dryness and discomfort. Eye drops offer relief of dry eyes, caused by airflow escaping from interface device.

Pain and anxiety can be optimally managed with reassurance, teaching and medications. Medications should be used with caution, and the clinician should reassess the patient for sedation or respiratory depression.

The team evaluates the response to noninvasive ventilation by assessing the patient’s symptoms, improved oxygenation and gas exchange, daytime wakefulness and increased function.⁶

**Weaning and Discharge Planning**

As with any mode of mechanical ventilation, when the underlying cause is corrected, the support may be weaned. For patients requiring NPPV for health maintenance when the cause isn’t correctable, the healthcare team decides whether it’s necessary for discharge planning. Devices with backup rates require different parameters for qualification for insurance coverage and aren’t covered for OSA.

Patients with restrictive lung diseases, central sleep apnea, OSA and severe COPD have to have certain test findings before insurance will cover the device for home use. Overnight continuous recording with the usual oxygen delivery volume captures possible desaturation events to document OSA. OSA requires a formal polysomnogram at a sleep disorder center to gather data on sleep patterns and apneic episodes. A full-night study in an attended sleep lab allows for data gathering and titration of CPAP or bilevel therapy. The goals are to adjust pressure to maintain patent airway, improve oxygenation and provide restful sleep.

Other options for home qualification include a “split-night study,” during which data are gathered in the lab, and then the patient returns home with his or her device and recommended settings. Unattended in-home titration is used with autotitration devices. There are no large-scale controlled studies on patient outcomes for CPAP titration strategies. Tracking compliance by using a CPAP unit with recording capability for duration is preferable to relying on patient self-reports, which are less accurate.³

Some patients with NPPV are discharged to assisted living or skilled nursing facility care. A discharge planner may find it difficult to place patients in such facilities, because many facilities lack caregivers skilled in NPPV, and lack reimbursement for the cost of NPPV.

Discharge teaching must involve the patient and the family. Teaching includes the application and removal of the device, safety strategies, maintenance and troubleshooting. Remind the patient and family that initially sleep patterns may be altered as the patient acclimates to sleeping with a device strapped to his or her face. This adaptation phase is the biggest challenge to adjusting to the use of NPPV.
Steps for Discharge Planning

Questions to ask —

- Has the underlying condition been corrected?
- Is the patient stable without NPPV?

If the answer to either or both are no, the team decides whether the patient can benefit from bilevel ventilation for discharge planning. A clear diagnosis for need of NPPV from the physician is necessary to accurately proceed with any discharge process.

Things to consider as the process continues —

- What settings are providing comfort? Is a backup rate necessary?
- What interface device is comfortable?
- Is oxygen being used as support, and is it at a flow realistic for home delivery (optimally less than 6 liters)?
- What resources do patients have at home or at the discharge facility?
  - Are they independent with device use, or do they need help?
  - Are they able to understand teaching and demonstrate learning?
  - Does the facility have the resources to use NPPV and possible oxygen?
- What financial resources or insurance coverage does the patient have to cover the cost of NPPV?
- What data need to be obtained to qualify for coverage, based on Medicare guidelines?
  - OSA and central sleep apnea are documented by setting an appointment at a formal sleep lab.
  - Severe COPD usually requires an ABG while awake and recorded sleep oximetry with baseline oxygen to show desaturation event of five minutes.
  - Restrictive thoracic disorders, including severe neuromuscular diseases, require an ABG while awake or recorded sleep oximetry with baseline oxygen to show desaturation event of five minutes or pulmonary function less than predicted.

For a fact sheet detailing what you should know if you need Medicare-covered equipment or supplies, go to www.medicare.gov/Publications/Pubs/pdf/11307.pdf.

NPPV provides an exciting alternative to manage ventilation for the acute care patient. Multidisciplinary knowledge and planning can enhance patient tolerance and improve outcomes.

References


