Noninvasive Mechanical Ventilation: What Have We Learned?

The application of noninvasive mechanical ventilation has been a rapidly emerging technology over the past decade and one that requires a critical understanding by the respiratory therapist.

In Dr. Hill’s experience at his institution, approximately 10 to 15 percent of patients presenting with acute respiratory failure are supported by noninvasive mechanical ventilation. Over the next decade, he anticipates this level of usage will be consistent across the country.

In the chronic care setting, surveys from Minnesota suggest from 1992 to 1997 that usage of noninvasive ventilation rose from negligible to 70 percent. In his special lecture, Dr. Hill focused on what we have learned as well as those areas where greater understanding is required.

Noninvasive ventilation offers significant advantages to the patient, including normal use of the upper airway and increased comfort. Early attempts at noninvasive ventilation occurred as early as the late 1700s in Amsterdam. The iron lung and rocking beds are early examples in many of our memories. The noninvasive positive pressure ventilation (NPPV) method arrived with the treatment of sleep disorders with continuous positive airway pressure (CPAP).

The middle 1980s brought the combination of portable ventilators and CPAP together in the treatment of chronic respiratory failure from restrictive thoracic processes. This combination, providing nocturnal nasal ventilation, proved very effective in improving gas exchange and alleviating symptoms. A review of nine studies between 1987 and 1992 comprised of 132 patients had only eight failures.

None of the studies were controlled; but the success rate was so high, it became unethical to pursue randomized controlled studies. A long-term outcome study from France over six years showed a survival rate of more than 80 percent. The disease processes in the

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patient population studied included neuromuscular disease, polio, and chest-wall deformities.

**Chronic respiratory failure**

Noninvasive ventilation is the modality of first choice in patients with chronic respiratory failure. The Health Care Financing Administration (HCFA) has outlined specific guidelines for the application of noninvasive ventilation.

Patients should:
- Be symptomatic
- Have evidence of either gas exchange or severe pulmonary function defect
- Have daytime carbon dioxide retention
- Have evidence of sustained hypoventilation at night as shown by sustained nocturnal desaturation
- Have severe decrease in forced vital capacity with the appropriate neuromuscular or chest-wall deformity.

NPPV is the preferred mode for patients with neuromuscular disease, chest-wall deformities, or central hypoventilation. Unfortunately, the best time to start NPPV is not well understood. Starting NPPV too early, prior to symptoms, may decrease adherence. Dr. Hill also pointed out that another controversial area is the appropriate time to switch the patient to invasive ventilation. These issues need further research and clarification, he said.

**Severe stable COPD**

The efficacy of NPPV in severe stable chronic obstructive pulmonary disease (COPD) is a more contentious issue. The potential mechanisms by which NPPV may be efficacious in stable COPD include several theories, one being the muscle-resting theory. This theory states that the severe COPD patient is hyperinflated with severe mechanical dysfunction of the muscles leading to chronic muscle fatigue. Resting the muscles for several hours each day may restore function with ultimately improved gas exchange and overall function.

Another theory involves sleep-disordered breathing. The severe COPD patient is well known to have a higher incidence of sleep-disordered breathing than in the normal population. The quality of sleep is poor with a greater number of arousals. The application of NPPV at night will avoid the hypoventilation, decrease the number of arousals, and improve gas exchange and quality of sleep. This should translate into better overall function.

During the 1980s, several studies were performed with negative pressure ventilation to evaluate the muscle-resting theory. The studies were mixed in terms of positive and negative outcomes. One thing consistent throughout the
negative-pressure ventilation studies was the severe COPD patient’s disdain for negative ventilation. Subsequently, studies were performed with NPPV. Four trials have been published with positive results, but only one is a controlled study. Each study found a significant decrease in daytime PCO$_2$ (partial pressure of carbon dioxide).

Two of the studies found an increase in the quality of life. The controlled study found a decrease in hospitalizations and improvement in sleep quality. The initial PCO$_2$ was 59. The negative studies found no change, but the initial PCO$_2$ was 50. A striking difference in the favorable versus unfavorable studies is the baseline characteristics of the patient population studied. The favorable studies are from a population with a higher baseline PCO$_2$ and incidence of sleep-disordered breathing.

Dr. Hill summarized the findings regarding the application of NPPV in severe stable COPD. Normocapnic or mildly hypercapnic patients appear to derive no benefit from NPPV, but severely hypercapnic COPD patients do appear to derive a benefit. HCFA has recently published guidelines for use of NPPV in the severe stable COPD patient. Nevertheless, the proof that this is an efficacious therapy is not well established. The questions concerning how NPPV works in the stable COPD population and appropriate patient selection criteria remain to be answered. Two uncontrolled studies, however, do show promise with a decrease in hospitalizations after NPPV is initiated.

**The acutely ill COPD patient**

The possibility of reducing work of breathing, thereby averting respiratory failure and the need for intubation, gave rise to the investigation of the application of
NPPV in the acutely ill COPD patient. Five controlled studies published in this population highly support the hypothesis. Avoiding intubation occurred in about 50 percent of the controlled population versus 80 percent of the study population. Some of these studies also support a decrease in length of stay and mortality. This is the modality of first choice in carefully selected patients. For patients where COPD is not the cause of acute respiratory failure, the controlled data is limited. The selection criteria in this population is not well defined. The clinician may use the selection criteria for COPD as a reference point. Cut-off criteria, such as respiratory rate, may need to be adjusted based on the disease process.

**Other applications**

The controlled studies in acute pulmonary edema suggest that CPAP alone is highly effective in averting intubation. Currently, there is no data to support NPPV as a better modality for treating pulmonary edema. Hypoxemic respiratory failure has also been researched in a controlled study. Unfortunately, the category is so broad it is difficult to apply the results to specific patients. A primary benefit of NPPV in this group is a reduction in nosocomial infections. NPPV has been applied as a weaning technique. One controlled study documented a reduction in pneumonia, less time on the ventilator, a higher percentage of patients weaned, less time in the intensive care unit, and an improved survival rate. Although the study shows promise, Dr. Hill expressed reservations due to experiences in his own study. As a weaning technique and applied to other causes of acute respiratory failure, NPPV requires further study.

**Summary**

Therapists need to understand each interface, advantages, and disadvantages as applied to each patient. Multiple technological advances have occurred in the masks. Dr. Hill pointed out that the type of ventilator to select is still controversial but that the selection of the device related to the care setting might be a consideration.

Most importantly, the therapist applying the modality must be knowledgeable. Dr. Hill emphasized the role of the respiratory therapist in visually monitoring the patient. During the first eight hours, it is the respiratory therapist who works with the patient toward a successful outcome. Dr. Hill described the respiratory therapist as the linchpin for successful application of NPPV.

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