

## Abstract

Negative pressure ventilation (NPV), including biphasic cuirass ventilation (BCV) delivered by systems such as the Hayek RTX Biphasic Cuirass Ventilator, represents a versatile and physiology-aligned modality that may influence clinical trajectories across a range of critical care scenarios.

While patient selection remains dependent on clinician judgment, growing clinical experience suggests that early and strategic application of NPV may provide meaningful support in preventing escalation of respiratory failure, facilitating recovery, and extending care beyond the ICU.

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## Intubation Avoidance and Early Stabilization

Avoiding endotracheal intubation when clinically appropriate remains a central objective in modern critical care.

Negative pressure ventilation offers a noninvasive means of supporting ventilation through **continuous or intermittent negative extrathoracic pressure**, which may help restore lung volumes—particularly **functional residual capacity (FRC)**—early in the course of respiratory compromise.

Restoration of FRC is closely associated with:

- improved oxygenation (P/F and S/F ratios)
- reduced work of breathing
- improved ventilation-perfusion matching

In selected patients with hypoxemic respiratory failure, application of NPV has been associated with rapid physiologic improvements, potentially stabilizing patients before further escalation of care is required.

In this context, NPV may serve as an additional option alongside high-flow oxygen and noninvasive positive pressure ventilation, particularly in patients who are intolerant of mask-based therapies or where airway pressurization is undesirable.

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## A Tool for Changing Clinical Trajectory

Early application of BCV may influence the trajectory of respiratory failure by addressing underlying physiologic deficits rather than solely supporting gas exchange.

Through thoracic expansion and lung recruitment, NPV may:

- improve oxygenation efficiency
- reduce respiratory rate and heart rate
- decrease work of breathing

- support more uniform lung ventilation

In some reported clinical experiences, NPV has been used as part of a broader strategy to stabilize patients receiving advanced support, including those transitioning from invasive ventilation or extracorporeal support. These observations highlight its potential role as a **complementary physiologic intervention** rather than a replacement for established therapies.

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### **Transitional Support in Difficult-to-Wean Patients**

Failure to liberate patients from mechanical ventilation remains a major contributor to prolonged ICU stays.

Negative pressure ventilation may offer a **bridge between invasive ventilation and spontaneous breathing** by:

- supporting ventilation while allowing respiratory muscle engagement
- reducing work of breathing without fully replacing patient effort
- assisting gradual recovery of diaphragmatic function

Use of NPV during the peri-extubation period may support smoother transitions by maintaining lung volumes and reducing physiologic stress during spontaneous breathing trials.

In selected patients, application before, during, or after extubation may contribute to:

- improved tolerance of weaning
  - reduced need for re-intubation
  - shorter duration of invasive ventilation
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### **Lung Recruitment and Restoration of Functional Residual Capacity**

Loss of lung volume and atelectasis are common contributors to respiratory failure and prolonged recovery.

Negative pressure ventilation facilitates lung inflation through **thoracic decompression**, which may promote recruitment of dependent lung regions and restoration of physiologic lung volumes.

This mechanism supports:

- stabilization of alveoli
- reduction in cyclic collapse and reopening
- improved ventilation-perfusion matching

Biphasic cuirass systems may also provide controlled expiratory phases that support lung stability, further contributing to maintenance of FRC.

Clinically, these effects have been associated with improvements in:

- oxygenation indices (P/F, S/F ratios)
  - respiratory mechanics
  - overall ventilatory efficiency
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### **Airway Clearance and Bronchiectasis**

Effective secretion management is essential in patients with impaired mucociliary clearance, including those with bronchiectasis or prolonged critical illness.

Negative pressure ventilation may enhance secretion mobilization by:

- augmenting physiologic airflow patterns
- improving distribution of ventilation within the lung
- supporting more effective cough mechanics

Some systems, including the Hayek RTX Biphasic Cuirass Ventilator, incorporate **timed secretion clearance modes**, combining high-frequency chest wall oscillation with phases that support cough and expiratory flow.

This integrated approach may assist with:

- mobilization of retained secretions
- reduction in airway obstruction
- improvement in lung aeration

In patients with bronchiectasis, where secretion retention contributes to recurrent infection and declining lung function, these capabilities may offer an additional tool for supporting airway clearance alongside conventional therapies.

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### **Procedural and Peri-Interventional Support**

Negative pressure ventilation has also been utilized in procedural settings where maintaining spontaneous breathing and avoiding airway instrumentation may be advantageous.

Clinical experience has included use during:

- bronchoscopic procedures
- selected sedation or anesthesia scenarios
- peri-intubation and peri-extubation support

In these contexts, NPV may provide ventilatory assistance while preserving airway access and reducing the need for deeper sedation in appropriately selected patients.

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### **Adjunctive Use with Existing Respiratory Therapies**

Negative pressure ventilation can be integrated with existing respiratory support modalities as part of a multimodal strategy.

Reported applications include use alongside:

- high-flow oxygen therapy
- noninvasive positive pressure ventilation
- invasive mechanical ventilation
- extracorporeal support

Because NPV does not rely on continuous positive airway pressure, it may be applied intermittently or concomitantly in a manner that supports ventilation without further increasing intrathoracic pressure.

This flexibility allows clinicians to use NPV as:

- a primary noninvasive support modality in selected patients
  - a bridge between levels of support
  - an adjunct to enhance lung recruitment and secretion clearance
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### **Extending Respiratory Support Across the Continuum of Care**

Patients recovering from respiratory failure often require ongoing support beyond the ICU.

Negative pressure ventilation systems designed for portability may allow continuation of respiratory support across:

#### **ICU → step-down → rehabilitation → home**

This continuity may contribute to:

- expanded discharge options
- earlier transitions to lower-acuity settings
- reduced reliance on invasive ventilation
- stabilization of chronic respiratory insufficiency

In some care models, this approach has been associated with reduced healthcare utilization and improved patient experience, particularly when respiratory support can be maintained outside the

hospital environment.

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### **Patient-Centered Advantages**

Because ventilation is delivered externally without a mask or airway instrumentation, patients using NPV may, when clinically appropriate:

- communicate verbally
- eat and drink
- participate in early mobilization

These factors may contribute to improved comfort and engagement in recovery, particularly in frail or prolonged-stay patients.

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### **Integrative Perspective**

Negative pressure ventilation represents a **physiology-aligned, highly adaptable modality** that may complement existing respiratory support strategies across a wide range of clinical scenarios.

Its potential impact is most pronounced when applied thoughtfully and, in some cases, early in the course of respiratory compromise—before escalation to more invasive or less tolerated therapies becomes necessary.

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### **Closing Perspective**

While modern critical care has been built around positive pressure ventilation, evolving priorities—including lung protection, reduced sedation, earlier mobility, and care beyond the ICU—are driving renewed interest in approaches that more closely align with natural respiratory physiology.

Negative pressure ventilation, particularly in the form of biphasic cuirass systems such as the Hayek RTX Biphasic Cuirass Ventilator, offers a compelling addition to the clinician's toolkit.

In selected patients, its use may help:

- prevent intubation
- support ventilator liberation
- improve lung recruitment and secretion clearance
- extend respiratory support across the continuum of care

As experience continues to grow, the role of NPV in adult critical care may expand as part of a broader shift toward more physiologic, patient-centered ventilation strategies.

Contact us at Hayek Medical to take advantage of strategic applications of this physiologic approach.

<https://hayekmedical.com/contact-us/>