HAYEK MEDICAL

SUMMARY: Maintenance Negative Pressure Ventilation Improves Survival in COPD Patients with Exercise Desaturation

In 2015 a group of researchers released a conference abstract **Negative pressure ventilation decreases lung function decline, acute exacerbations and hospitalizations in COPD patients with desaturation during 6 minute walk test** **European Respiratory Journal Oct 2015 46:.** This was the first of several papers on the topic of the use and benefit of Negative Pressure Ventilation (NPV) for COPD patients and the first look at exercise retraining combined with the application of NPV via cuirass. These papers drew data from their treatment of COPD patients going through pulmonary rehab at their clinic at the Department of Thoracic Medicine, Chang Gung Memorial Hospital, Taipei, Taiwan. This abstract reported results from a four year study with a group of 98 patients divided evenly into 2 groups. One performed weekly upper extremity training supported by NPV the other did not. They found significant improvements in comparison, stating in conclusion: "6MWD was significantly decreased at 3 year and end of 4 year in control group. The rate of ER visit and hospitalization was significantly decreased in the NPV-exercise group. In COPD with desaturation during 6MWT, additional therapy with hospital-based exercise training and NPV support was associated with improvement of exacerbations and hospitalizations, and preserved lung function during a 4-year period."

Their next paper on this topic was released in 2016, **Pulmonary rehabilitation coupled with negative pressure ventilation decreases decline in lung function, hospitalizations, and medical cost in COPD: A 5-year study** **Medicine: October 2016 - Volume 95 - Issue 41 - p e5119,** documenting the data collected from a group of 129 subjects divided into two groups. Pacing walking along with breathing training and relaxation techniques was taught to all patients and encouraged to be performed at home by the patients themselves. In the control group, they were reminded of, and and encouraged to perform regular home pacing walking exercise when they went back to the outpatient clinic for follow up and collection of 6 MWT and continued these at home routinely. The active group received NPV with breathing training via the cuirass ventilator settings for 60 min. along with the other elements of the program with goal of achieving 3 to 5 exercise sessions per week. These groups were followed for over 5 years. In this paper very clear differences were demonstrated. The data continued to show that a hospital-based multidisciplinary PR coupled with NPV reduced yearly decline of lung function, exacerbations, hospitalization rates, improved walking distance and medical costs.

The next two papers were quite similar, **Noninvasive negative pressure ventilation improves survival of COPD patients with exercise desaturation** **European Respiratory Journal Apr 2018 52: PA3347, and**
Maintenance Negative Pressure Ventilation Improves Survival in COPD Patients with Exercise Desaturation **April 2019 Journal of Clinical Medicine 8(4):56.**
In these papers they divided the 341patients into 4 groups. Non-desaturators and desaturators during 6MWT that were users of NPV supporting exercise and the control exercise at home group. In this paper subjects were followed and data presented from those groups collected over 8 years. Findings from prior study periods were reinforced, for physical and cost elements, but there was also a very strong mortality finding demonstrated. The study ultimately showing *"The 8-year survival probabilities for the NPV and Non-NPV groups were 60% and 20%, respectively… The NPV group had a slower decline in lung function and 6MWD…Maintenance non-invasive NPV reduced long-term mortality in COPD patients."*
What follows is a detailed summary of what was demonstrated and learned about the use of NPV as a tool to improve outcomes in COPD population from Huang et al 2019.

Summary of Hung-Yu Huang, Chun-Yu Lo, Lan-Yan Yang, Fu-Tsai Chung, Te-Fang Sheng , Horng-Chyuan Lin, Chang-Wei Lin, Yu-Chen Huang, et al
Maintenance Negative Pressure Ventilation Improves Survival in COPD Patients with Exercise Desaturation, April 2019 Journal of Clinical Medicine 8(4):562

This paper explains that maintenance negative pressure ventilation (NPV)—the physiologic basis for modern Biphasic Cuirass Ventilation (BCV)—appears to help COPD patients through several interconnected mechanisms that directly address the major drivers of COPD progression, exacerbation, hospitalization, and death.
The authors repeatedly connect clinical improvements to four major physiologic effects:

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1. BCV/NPV REDUCES THE WORK OF BREATHING

The paper states NPV helps by:

- "unloading inspiratory muscles"
- "decreasing the work of breathing"
- improving breathing patterns

COPD patients often breathe against:

- airflow obstruction
- hyperinflation
- trapped air
- flattened diaphragms

Over time this creates:

- respiratory muscle fatigue
- dyspnea
- reduced activity tolerance
- progressive physiologic decline

The paper suggests BCV assists breathing externally, reducing the energy expenditure required to ventilate.
Clinical effect:

- less respiratory fatigue
- less dyspnea
- improved endurance
- improved exercise tolerance

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2. BCV/NPV IMPROVES VENTILATION AND GAS EXCHANGE

This is one of the central themes of the paper.
The authors explain that COPD desaturation during exertion is driven by:

- dynamic hyperinflation
- ventilation/perfusion (V/Q) mismatch
- impaired gas exchange

They specifically state NPV:

- "improves ventilation inhomogeneity"
- improves "gas exchange"
- improves "ventilation/perfusion mismatch"

- reduces “shunting”
- reduces hypoxemia during exercise

In simpler terms:
Many COPD lungs ventilate unevenly.
Some regions:

- trap air
- overinflate
- ventilate poorly
- receive mismatched blood flow

The paper suggests BCV helps recruit and ventilate lung regions more physiologically, improving oxygenation efficiency.
Clinical effect:

- less exertional desaturation
- improved oxygen delivery
- improved walking capacity
- less physiologic stress during activity

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3. BCV/NPV MAY REDUCE DYNAMIC HYPERINFLATION

This is extremely important mechanistically.
The paper repeatedly references:

- hyperinflation
- residual volume
- impaired inspiratory capacity

Dynamic hyperinflation is a major cause of:

- dyspnea
- exercise intolerance
- worsening V/Q mismatch
- respiratory muscle disadvantage

The authors suggest NPV may:

- improve lung expansion
- improve emptying
- reduce trapped air
- improve inspiratory mechanics

They compare this to known benefits seen with BiPAP, but suggest NPV may accomplish similar physiologic goals through a more natural breathing mechanism.
Clinical effect:

- easier inhalation
- improved tidal volume
- improved exercise capacity
- slower functional decline

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4. BCV/NPV IMPROVES SECRETION CLEARANCE

The paper specifically references:

- mucus plugging
- sputum clearance
- atelectasis prevention

They propose that NPV:

- increases pulmonary perfusion
- assists mucus clearance
- improves clearance of mucus plugging associated with atelectasis

This is highly relevant because retained secretions:

- worsen infection risk
- worsen airflow obstruction
- worsen V/Q mismatch
- trigger exacerbations

Clinical effect:

- fewer exacerbations
- reduced infection burden
- reduced hospitalization risk

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5. BCV/NPV MAY SLOW COPD PROGRESSION

One of the most compelling findings:

The NPV groups had:

- slower FEV_1 decline
- slower decline in walking distance
- slower deterioration in functional status

The paper reports:

- NPV groups lost ~19–20 mL/year FEV_1
  vs.
- Non-NPV groups lost ~35–42 mL/year

That is a major difference.

The authors suggest this may occur because reducing:

- hypoxemia
- exacerbations
- hyperinflation
- respiratory muscle stress
- helps reduce cumulative lung injury over time.

Clinical implication:

BCV may not merely palliate symptoms—it may alter disease trajectory.

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6. BCV/NPV REDUCES EXACERBATIONS AND HOSPITALIZATIONS

The authors strongly connect physiologic stabilization with reduced acute care utilization.

NPV groups had:

- fewer ER visits
- fewer hospitalizations
- fewer exacerbations

The proposed mechanism:

BCV keeps patients from crossing the threshold into acute decompensation by:

- improving ventilation
- reducing fatigue
- improving secretion clearance
- reducing hypoxemia

This is one of the most clinically important concepts in the paper.

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7. BCV/NPV MAY IMPROVE SURVIVAL THROUGH MULTIPLE PATHWAYS

The survival signal is likely multifactorial.

The paper proposes mortality improvement may result from:

- fewer exacerbations
- less hypoxemia
- less systemic inflammation
- improved exercise capacity
- slower lung function decline
- reduced dynamic hyperinflation

The authors emphasize that exertional desaturation itself predicts mortality.

Patients who desaturated severely during 6MWT had:

- 3–4x higher mortality risk

NPV appeared to partially offset that risk.

MOST IMPORTANT OVERALL MESSAGE OF THE PAPER

The paper's central idea is this:

COPD decline is not driven only by baseline airflow obstruction.

It is driven by a cycle of:

- exertional desaturation
- hyperinflation
- respiratory muscle fatigue
- worsening gas exchange
- exacerbations
- hospitalization
- progressive physiologic decline

The authors argue that maintenance NPV interrupts that cycle.

Their conclusion is essentially:

BCV/NPV helps COPD patients by stabilizing the physiology that drives progression and acute deterioration—not simply by temporarily assisting ventilation.

STRONGEST CLINICAL TAKEAWAYS FOR CLINICIANS

This paper suggests BCV may:

- reduce exertional desaturation
- unload respiratory muscles
- improve ventilation distribution
- reduce dynamic hyperinflation
- improve mucus clearance
- reduce exacerbations
- slow lung function decline
- preserve exercise capacity
- reduce hospitalization
- improve survival

especially in:

- frequent exacerbators

- exercise desaturators
- advanced COPD patients
- patients with progressive decline despite standard therapy

STRONGEST VALUE-BASED TAKEAWAYS

The paper frames COPD progression as a utilization problem driven by physiologic instability. BCV/NPV appears to:

- stabilize high-risk patients
- reduce acute care utilization
- preserve function
- reduce decline
- potentially improve survival

That creates a compelling value proposition in:

- readmission reduction
- population health
- pulmonary rehabilitation
- value-based COPD management
- home stabilization programs

END OF SUMMARY

NPV/BCV used routinely supportive of an exercise program and other COPD care strategies has great potential for both cost and physical outcome improvements for patients with COPD symptoms. Intervention with this modality earlier rather than later in the progression of this illness can make the most difference for long term improvements in health maintenance, costs of care, quality of life and mortality.