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The addition of non-invasive ventilation during exercise training in COPD patients

Enrico Clini and Michelle Chatwin
X I have no real or perceived conflicts of interest that relate to this presentation.

☐ I have the following real or perceived conflicts of interest that relate to this presentation:

<table>
<thead>
<tr>
<th>Affiliation / Financial interest</th>
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**Conflict of interest disclosure Michelle Chatwin**

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<td>Grants/research support:</td>
<td>Educational grant from ResMed to provide education for the ERS NIV simulator</td>
</tr>
<tr>
<td>Honoraria or consultation fees:</td>
<td>Honorarium received from B&amp;D electromedical for non commercial education days on NIV and cough augmentation techniques. Honorarium received from Resmed for non commercial education days on NIV</td>
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INTRODUCTION

AIMS

• Discuss the role of non-invasive ventilation as a potential ergogenic aid to exercise in COPD
• Report the clinical available evidence to train severe COPD patients assisted by non-invasive techniques during a rehabilitation course
• Discuss the actual limitations of such a strategy in this population
INDICATIONS FOR NIV DURING EXERCISE
Exercise training (ET) significantly improves both exercise tolerance and QoL in COPD.

The intensity of ET is crucial to achieve a true physiologic effect.

In severe severe COPD, exertional dyspnea and leg fatigue could impede to maintain intensity of training for enough time to yield a physiologic training effect.
FACTORS CONTRIBUTING TO DYSPNEA

- Increased intrinsic mechanical loading of the inspiratory muscles (hyperinflation)
- Increased mechanical restriction of the chest wall (hyperinflation)
- Functional inspiratory muscle weakness
- Increased ventilatory demand related to capacity
- Gas exchange abnormalities
- Cardiovascular effects
- Dead space
Dynamic Hyperinflation and Exercise Intolerance in Chronic Obstructive Pulmonary Disease

Marin JM, AJRCCM 2001; 163: 1395-99
NIV AND ACUTE EFFECT ON EXERCISE

- **Improves respiratory sensation in COPD** by unloading IM
  - O’Donnell et al. ARRD 1988; 138: 1185-91
- **Reduces inspiratory muscle effort in COPD**
  - Petrof et al. JAP 1990; 69: 179-88
- **Reduces the work of breathing and increase tolerance in CF**
- **Increases the endurance time**
  - Bianchi L. ERJ 1998 11: 422
- **Improves gas exchanges**
  - Dreher M ERJ 2007; 29:930
PSV DURING EXERCISE IN COPD PATIENTS: UNLOADS RESPIRATORY MUSCLES AND REDUCES DYSPNEA

Maltais, AJRCCM, 1995; 151:1027
BLOOD FLOW DISTRIBUTION DURING ARF

- Distribution of blood flow during SB or CPAP (10 mbar)

“minimizing mechanical work of breathing and therefore the metabolic cost of breathing allows for a greater amount of cardiac output to be available for delivery to working limb muscles”

(Harms C, J. Appl. Physiol)
Respiratory muscle unloading improves leg muscle oxygenation during exercise in patients with COPD

![Graph showing tissue oxygenation index over exercise duration (as % of isotime)]

PAV
Control

Effects of proportional assist ventilation on exercise tolerance in COPD patients with chronic hypercapnia

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Control</th>
<th>Sham</th>
<th>CPAP</th>
<th>PSV</th>
<th>PAV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endurance time min (min)</td>
<td>7.1±4.6</td>
<td>7.2±4.4</td>
<td>9.6±4.6*</td>
<td>10.5±2*</td>
<td>12.5±6**§#</td>
</tr>
<tr>
<td>Borg dyspnoea isotime</td>
<td>6.3±1.4</td>
<td>6.5±1.5</td>
<td>5.3±1.9*</td>
<td>4.4±1.4**§</td>
<td>4.2±1.9*</td>
</tr>
<tr>
<td>Borg leg discomfort isotime</td>
<td>5.0±2.6</td>
<td>5.4±1.9</td>
<td>4.9±2.3*</td>
<td>4.1±2.2*</td>
<td>4.2±2.3*</td>
</tr>
<tr>
<td>(\text{O}_2) supply isotime (L·min(^{-1}))</td>
<td>3.8±1.8</td>
<td>3.9±1.9</td>
<td>3.7±2.0</td>
<td>3.1±1.8**§</td>
<td>3.4±1.9*</td>
</tr>
</tbody>
</table>

Noninvasive ventilation during walking in patients with severe COPD: a randomised cross-over trial

M. Dreher, J.H. Storre and W. Windisch

\[
\begin{align*}
\text{suppl. } O_2 & \quad P < 0.001 \\
\text{suppl. } O_2 + \text{NPPV} & \quad P < 0.001
\end{align*}
\]

\[
\begin{align*}
\text{PaO}_2 & \text{ (mmHg)} \\
\text{mean} & \quad \text{before} & \quad \text{after} & \quad \text{mean} \\
\text{mean} & \quad \text{before} & \quad \text{after} & \quad \text{mean}
\end{align*}
\]

\[
\begin{align*}
\text{PaCO}_2 & \quad 50 \quad \text{P < 0.001} \quad 53 \\
\end{align*}
\]

NIV AND EXERCISE
CLINICAL RESULTS
LACK OF ADDITIONAL EFFECT OF ADJUNCT OF ASSISTED VENTILATION TO PULMONARY REHABILITATION IN MILD COPD PATIENTS

• Assisted ventilation during training sessions was not well tolerated by all patients (drop-out 28%) and gave no additional physiological benefit in comparison with exercise training alone.

(Bianchi L. Resp Med 2002)
Group mean training intensity

Training intensity (% Peak Work rate)

PAV
SB

Training session
Individual changes in 6MWD and Peak work rate

6 MWD (m)

Before | After 18 TS
---|---

200 | 250 | 300 | 350 | 400 | 450 | 500 | 550 | 600 | 650 | 700

Before | After 18 TS
---|---

PAV

SB

Peak Work rate (watt)

Before | After 18 TS
---|---

30 | 50 | 70 | 90 | 110 | 130 | 150 | 170

Before | After 18 TS
---|---

Individual changes in 6MWD and Peak work rate
PROPORTIONAL ASSIST VENTILATION AS AN AID TO EXERCISE TRAINING IN SEVERE COPD

Hawkins P.  *Thorax* 2002;57:853–859
PROPORTIONAL ASSIST VENTILATION AS AN AID TO EXERCISE TRAINING IN SEVERE COPD

- 19 pts; FEV1 27% : 10 PAV+Tr; 9 Tr
- Peakwork 18% higher in PAV
- Lactates 30% lower in PAV

Hawkins P. *Thorax* 2002; 57:853–859
Figure 2. Change in incremental shuttle walking distance with training.

PS = 10

Sham
PHYSICAL TRAINING AND NIV IN COPD PATIENTS: A META-ANALYSIS

- Heterogeneous drop-out rate: from 7.1% in the study by Borghi-Silva to 28% in the study by Bianchi

(Ricci, Respir Care 2014)
<table>
<thead>
<tr>
<th>Subjects (n)</th>
<th>COPD Severity</th>
<th>Training</th>
<th>Mask</th>
<th>Ventilator mode</th>
<th>Pressure</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Johnson 2002</td>
<td>39</td>
<td>Severe</td>
<td>Treadmill</td>
<td>Nasal</td>
<td>Bi-Level</td>
<td>IPAP 8-12 EPAP 2</td>
</tr>
<tr>
<td>Bianchi 2002</td>
<td>33</td>
<td>Mild to Mod</td>
<td>Cycle</td>
<td>Nasal and FFM</td>
<td>PAV</td>
<td>6.6 (VA 2.2L) 3.5 (FA 1.6L per s)</td>
</tr>
<tr>
<td>Hawkins 2002</td>
<td>19</td>
<td>Severe</td>
<td>Cycle</td>
<td>FFM</td>
<td>PAV</td>
<td>12.7 (VA 1.5L) 3.6 (FA 0.7L per s)</td>
</tr>
<tr>
<td>Reuveny 2005</td>
<td>24</td>
<td>Mod to severe</td>
<td>Treadmill</td>
<td>FFM</td>
<td>Bi-level</td>
<td>IPAP 7-10 EPAP 2</td>
</tr>
<tr>
<td>Van ‘t Hul 2006</td>
<td>29</td>
<td>Mod to severe</td>
<td>Cycle</td>
<td>Mouth-piece</td>
<td>IPS</td>
<td>10</td>
</tr>
<tr>
<td>Toledo 2007</td>
<td>18</td>
<td>Mod to severe</td>
<td>Treadmill</td>
<td>Nasal</td>
<td>Bi-Level</td>
<td>IPAP 10-15 EPAP 4-6</td>
</tr>
<tr>
<td>Cotes 2003</td>
<td>14</td>
<td>Mod to severe</td>
<td>Cycle</td>
<td></td>
<td>Bi-Level</td>
<td>IPAP ? EPAP 4-8</td>
</tr>
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Adapted from Piper and Menadue, *Breathe*. 2009
...however, these findings are not consistent across other measures of exercise capacity. There is no clear evidence that HRQL is better or worse with NIV during training.
NIV AND EXERCISE
USEFULNESS AND GOALS IN
THE CLINICAL PRACTICE
LIKELY BENEFITS IN CLINICAL PRACTICE

- Performance in more severe individuals
- Fasten recovery following acute care
- Low health care resources?
- Low mortality?
Supported Arm Training in Patients Recently Weaned From Mechanical Ventilation

Roberto Porta, MD; Michele Vitacca, MD; Lucia Sonia Gile, MD; Enrico Cimini, MD, FCCP; Luca Bianchi, MD; Ercole Zuzotti, MD; and Nicolino Ambrosino, MD, FCCP

(CHEST 2005; 128:2511–2520)

Conclusion: Early upper-limb exercise training is feasible in ICU patients recently weaned from MV and can enhance the effects of gPT. Baseline inspiratory muscle function is related to exercise capacity improvement. (CHEST 2005; 128:2511–2520)
Noninvasive ventilation during walking in patients with severe COPD: a randomised cross-over trial

M. Dreher, J.H. Storre and W. Windisch

Walking with a rolator and High-intensity NIV is better than oxygen alone for hypercapnic COPD on Home NIV

N=20

6MWT

Oxygen

NIV+Oxygen

222.0 ± 84.8

260.7 ± 64.9
Noninvasive ventilation during walking in patients with severe COPD: a randomised cross-over trial

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6MWT

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Noninvasive ventilation during walking in patients with severe COPD: a randomised cross-over trial

M. Dreher, J.H. Storre and W. Windisch
Nocturnal non-invasive ventilation in addition to rehabilitation in hypercapnic patients with COPD

M L Duiverman,1 J B Wempe,1,2 G Bladder,1 D F Jansen,3 H A M Kerstjens,1 J G Zijlstra,4 P J Wijkstra1

Thorax 2008;63;1052-1057
NOCTURNAL NIV IN ADDITION TO REHABILITATION IN HYPERCAPNIC PATIENTS WITH COPD

Duiverman et al., Thorax, 2008
IN SUMMARY …. 

1. *By unloading the respiratory system NIV may prove effective during exercise in COPD patients*

2. *Clinical results are contractictory. More severe patients especially if following acute care are more likely to benefit from this strategy*