Pulmonary rehabilitation in severe COPD

daniel.langer@faber.kuleuven.be
Content

• Rehabilitation (how) does it work?
• How to train the ventilatory limited patient?
Chronic Obstructive Pulmonary Disease

NHLBI/WHO Global Initiative for Chronic Obstructive Lung Disease (GOLD) Definition:

- Chronic obstructive pulmonary disease is characterized by airflow limitation that is not fully reversible.

- It is a preventable and treatable disease with some significant extrapulmonary manifestations.
  - Skeletal muscle dysfunction
  - Weight loss
  - Cardiovascular disease
  - Depression and Fatigue
  - Osteoporosis
Interaction between pulmonary and extrapulmonary factors

Muscle Dysfunction
Early lactic acidosis
Dynamic Hyperinflation
Breathing frequency
Targets of Exercise Training

- Improving aerobic function of ambulation muscles
- Reducing ventilatory requirement and respiratory rate during exercise
- Prolonging expiration time
- Reducing dynamic hyperinflation and dyspnea

Content Rehabilitation Program

- Exercise Training
  - Endurance exercise to improve cardiorespiratory fitness
  - Resistance training to improve muscular strength and endurance (peripheral and respiratory muscles)

- Supplemental interventions during exercise training
  - Oxygen
  - Heliox

- Breathing exercises

- Occupational therapy

- Nutritional advise

- Psychological support

- Patient-education / self-management (inactivity)
Rehabilitation, the evidence: Exercise tolerance

Exercise tolerance: Weighted mean difference and IQR

Adapted from Troosters AJRCCM 2005
Rehabilitation, the evidence

CRDQ

Δ HRQoL (MCID-units)

Dys Fat Emo Mas

6MWD

Δ 6MWD (m)

Lacasse Eura Medicophys 2007 (Cochrane)
### Rehabilitation, the evidence: Health care resources

<table>
<thead>
<tr>
<th></th>
<th>Controls</th>
<th>Rehabilitation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Patients admitted n</strong></td>
<td>41</td>
<td>40</td>
</tr>
<tr>
<td><strong>Hospital admissions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resp</td>
<td>1.9</td>
<td>1.4</td>
</tr>
<tr>
<td>All</td>
<td>2.2</td>
<td>1.5</td>
</tr>
<tr>
<td><strong>Days spent in hosp</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resp</td>
<td>18.1</td>
<td>19.3</td>
</tr>
<tr>
<td>All</td>
<td>21.0</td>
<td>20.7</td>
</tr>
<tr>
<td><strong>Days per admission</strong></td>
<td>9 ± 7.6</td>
<td>6 ± 3.4</td>
</tr>
</tbody>
</table>

Griffiths Lancet 2000
Rehabilitation: the evidence

Evidence from systematic review of meta-analysis of randomised controlled trials (level Ia)
• Improvements in exercise tolerance
• Clinically relevant improvement in health related quality of life (HRQoL).

Evidence from at least one RCT(level Ib)
• Reductions in number of days spent in hospital
• Pulmonary rehabilitation is cost effective
Exercise training, the core of rehabilitation

How do we train patients with severe airflow obstruction, dynamic hyperinflation and complaints of dyspnea on exertion?
Knowing exercise limitations to guide training

How to train the ventilatory limited patient?

- Improve the lung function / maximum ventilatory capacity
- Reduce the ventilatory needs
  - Increase the delivery
  - Reduce the demand
Improve lung function

Casaburi et al. Chest 2005

Kesten J COPD 2008
Improve maximal voluntary ventilation

### HeliOx

<table>
<thead>
<tr>
<th></th>
<th>Air</th>
<th>HeliOx</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEV1</td>
<td>$1.54\pm0.73$</td>
<td>$1.89\pm0.73$</td>
</tr>
<tr>
<td>FVC</td>
<td>$3.76\pm1.13$</td>
<td>$3.86\pm1.18$</td>
</tr>
</tbody>
</table>

**Endurance time**

**VE**

Eves AJRCCM 2006
Training at higher intensity

Air (n=19)  He/O₂(n=19)

<table>
<thead>
<tr>
<th></th>
<th>Air</th>
<th>He/O₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEV₁</td>
<td>47 ± 19</td>
<td>46 ± 14</td>
</tr>
<tr>
<td>TLC</td>
<td>129 ± 20</td>
<td>122 ± 17</td>
</tr>
<tr>
<td>D_LCO</td>
<td>66 ± 22</td>
<td>64 ± 14</td>
</tr>
<tr>
<td>VO₂peak</td>
<td>55</td>
<td>11</td>
</tr>
</tbody>
</table>

Endurance time

Eves Chest 2009
Lung Transplantation
<table>
<thead>
<tr>
<th></th>
<th>1yPost-LTX n=22</th>
<th>Healthy n=30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>♂ / ♀</td>
<td>18 / 12</td>
</tr>
<tr>
<td>Age yrs</td>
<td>59 ± 5</td>
<td>58 ± 6</td>
</tr>
<tr>
<td>BMI kg/m²</td>
<td>23 ± 4</td>
<td>25 ± 4</td>
</tr>
<tr>
<td>FEV₁ %pred</td>
<td>79 ± 18*</td>
<td>116 ± 18</td>
</tr>
<tr>
<td>Q-Force Nm</td>
<td>100 ± 36*</td>
<td>-40%</td>
</tr>
<tr>
<td>MEP cm H₂O</td>
<td>159 ± 44*</td>
<td>-20%</td>
</tr>
<tr>
<td>MIP cm H₂O</td>
<td>-76 ± 48</td>
<td>-20%</td>
</tr>
<tr>
<td>Handgrip kgF</td>
<td>36 ± 16</td>
<td>-15%</td>
</tr>
<tr>
<td>6MWD m</td>
<td>483 ± 66*</td>
<td>-30%</td>
</tr>
<tr>
<td>Wmax %pred</td>
<td>74 ± 22*</td>
<td>-60%</td>
</tr>
</tbody>
</table>
Study Design RCT
Exercise Training after LTX

Pre-LTX 105 days → Post-LTX 28 days

Exercise Training
Control

3m/6mPost-Random
# Baseline Characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Training (n=15)</th>
<th>Control (n=13)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male / Female</td>
<td>8 / 7</td>
<td>7 / 6</td>
</tr>
<tr>
<td>Early acute rejection (yes / no)</td>
<td>6 / 7</td>
<td>3 / 9</td>
</tr>
<tr>
<td>SLTX / SSLTX</td>
<td>1 / 14</td>
<td>3 / 10</td>
</tr>
<tr>
<td>Diagnosis COPD / ILD</td>
<td>12 / 3</td>
<td>11 / 2</td>
</tr>
<tr>
<td>Age</td>
<td>56 ± 4</td>
<td>56 ± 7</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>20.7 ± 4.6</td>
<td>21.6 ± 4.2</td>
</tr>
<tr>
<td>FEV₁ (% pred)</td>
<td>72 ± 18</td>
<td>74 ± 16</td>
</tr>
</tbody>
</table>
Exercise Training

- 3 sessions per week
Results

6-minute walking distance (m)

- Training
- Control

Pre-LTX  | Post-LTX  | 3mPost-LTX  | 6mPost-LTX

40  | 50  | 60  | 70  | 80  | 90

*
Knowing exercise limitations to guide training

How to train the ventilatory limited patient?

- Improve the lung function / maximum ventilatory capacity
- Reduce the ventilatory needs
  - Increase the delivery
  - Reduce the demand
Training at higher intensity

Increased O2 delivery
Lower lactate
Reduced ventilatory drive

Emtner AJRCCM 2003
Knowing exercise limitations to guide training

How to train the ventilatory limited patient?

- Improve the lung function / maximum ventilatory capacity
- Reduce the ventilatory needs
  - Increase the delivery
  - Reduce the demand
Reduce the demand

- Enhance the stress to the muscle for a given VO2 (walking vs cycling)

 VO₂ L/min

 Cycle @ 80% Wpeak
 Walk @ 80% VO₂peak

 Δ Qₜₘ pot (%baseline)
- Enhance the stress to the muscle for a given VO2 (walking vs cycling)
- Reduce the amount of muscle mass at work (resistance training, NMES).
Δ (% initial or points)

6MWD  VO2max  CRDQ

Reduce the demand

- Enhance the stress to the muscle for a given VO2 (walking vs cycling)

- Reduce the amount of muscle mass at work (resistance training, NMES, single leg)
Single leg exercise

Endurance Time (min)
@ 80% Wpeak

Healthy

COPD

two legs one leg

Dolmage et al. Chest 2006
Single leg training

30 min of conventional cycling training versus single leg cycling (15 min each leg)
3 times per week
7 weeks
FEV1 37 and 40% pred

![Graphs showing changes in Wpeak, VO2peak, and Tlim@80%](image-url)
Reduce the demand

- Enhance the stress to the muscle for a given VO2
- Reduce the amount of muscle mass at work
- Shorten the bouts of exercise to keep ventilation lower than needed in steady state (interval training)

Slow oxygen uptake (ventilatory) kinetics: your friend in pulmonary rehab...
Interval exercise, often more realistic
Conclusions

- Pulmonary rehabilitation works: ‘GRADE A’-level of evidence

- Exercise training can be fine-tuned to the exercise limitations of patients

- Several options available for ventilatory limited patients
Increase Ventilatory Capacity:
- Bronchodilators
- Heliox

High intensity Peripheral Muscle Training

Exercise training
Reduce Ventilatory Requirements:

- O₂ supplementation
- Small muscle mass
- Short intervals

High intensity Peripheral Muscle Training

One-leg exercise Interval training Resistance training
Thank you for your attention

Greetings from the Leuven Pulmonary Rehabilitation team