A Comparison of Two Methods of Noninvasive Ventilatory Support in Weaning from Mechanical Ventilation.

Authors: Bajcar L, Michalickova M, Magula D, Plutinsky J, Petricek S,
Introduction

The need for reintubation after extubation and discontinuation of mechanical ventilation (MV) is not uncommon and is associated with increased mortality.

Noninvasive ventilation has been suggested as a promising method for prevention and therapy of patients with respiratory failure after extubation.

In our ICU we use two methods of Noninvasive ventilation (NIV) for prevention of failure after extubation:

1. Bilevel positive airway pressure (BiPAP)
2. High frequency jet ventilation (HFJV)

Aim

To find out whether two methods of NIV (BiPAP and HFJLV) are equally effective in weaning from mechanical ventilation.
Methods

• We used retrospective analysis in group of patients who required MV
• Years 2007 and 2008
• Inclusion criteria – need of MV continuing at least 24 hours
• Exclusion criteria – patients after cardiopulmonary resuscitation
• For statistical analysis we applied Mann-Whitney test, ANOVA and Regression analysis.
Weaning from MV – clinical assessment

- Adequate (equally effective) cough
- Absence of excessive tracheobronchial secretion
- Resolution of acute phase of the disease for which the patient was intubated
- Stable cardiovascular and metabolic status
- Adequate consciousness
- No sedation
Weaning from MV
- Objective measurements

- Adequate oxygenation $\text{SaO}_2 > 90\%$  
  ($\text{FiO}_2 \leq 0.4$)
- PEEP $\leq 8 \text{ cmH}_2\text{O}$
- Respiratory frequency $\leq 35 \text{ breaths} \cdot \text{min}^{-1}$
- MIP $\leq 20-25 \text{ cm H}_2\text{O}$
- $VT > 5 \text{ ml} \cdot \text{kg}^{-1}$
- $VC > 10 \text{ ml} \cdot \text{kg}^{-1}$
- Airways closing pressure (CP) $< 7 \text{ cm H}_2\text{O}$
- $\text{PaO}_2 (\text{FiO}_2 = 0.4) > 60 \text{ mm Hg} (8 \text{ kPa})$
- Increasing $\text{PaCO}_2 < 8 \text{ mm Hg} (1 \text{ kPa})$
- $\text{pH} > 7.300$

MIP = maximal inspiratory pressure

$VT = \text{volume tidal}$

$VC = \text{vital capacity}$
Weaning from MV - Technique of weaning:

- We use assisted ventilatory modes
  (pressure support, SIMV, PAV, APRV)
- We use follow with Aeyr T-piece
  (spontaneous breathing trial)
- Extubation when possible
- Noninvasive ventilation
- Consistent monitoring of patients
Weaning from MV – use of BiPAP

- We applied BiPAP via nasal (facial) mask
- Every hour for the duration of twenty minutes
- $\text{FiO}_2 = 0.35$
- IPAP = 12-25 cm H$_2$O
- EPAP = 4-6 cm H$_2$O
- Medical device: BiPAP S/T D-30
Weaning from MV – use of HFJV

- We applied HFJV via facial mask
- Every hour for the duration of twenty minutes
- Respiratory frequency = 120 breaths per minute
- $\text{FiO}_2 = 0.65$
- Inspiratory press = 25 cm H$_2$O
- Inspiratory Time : Expiratory Time ratio = 1 : 1
- Medical device: Paravent PAT
Results

• 55 mechanical ventilated patients:
  33 died (60.00%)
  22c survived (40.00%)
• 34 patients, who met the criteria for weaning from MV
• 17 patients – BiPAP in weaning
• 17 patients – HFJV in weaning
• Reasons for need of MV are shown in graph 1

• Results in subgroup  34 patients

• 34 patients started weaning from MV
• Weaning was successful in 22 patients (64.71%)
• Weaning was not successful in  12 patients  (35.29%)
• The difference between successfully weaned patients and non-weaned patients was statistically significant: (p Mann-Whitney 0.0376)
## Characteristic of subgroup 34 patients

<table>
<thead>
<tr>
<th></th>
<th>Number</th>
<th>Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>survived</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>died</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Age * (years)</td>
<td></td>
<td>64.82 ± 9.84</td>
</tr>
<tr>
<td>BMI * (kg x m⁻¹)</td>
<td></td>
<td>31.36 ± 9.55</td>
</tr>
<tr>
<td>pH *</td>
<td></td>
<td>7.301 ± 0.050</td>
</tr>
<tr>
<td>PaCO₂* (kPa)</td>
<td></td>
<td>7.97 ± 2.36</td>
</tr>
<tr>
<td>PaO₂* (kPa)</td>
<td></td>
<td>5.68 ± 0.76</td>
</tr>
<tr>
<td>Leucocytes * (10⁹ / ml)</td>
<td></td>
<td>11.27 ± 5.05</td>
</tr>
<tr>
<td>CRP *(mg/ml)</td>
<td></td>
<td>61.42 ± 35.37</td>
</tr>
</tbody>
</table>

* Values at admission in mean ± SD
### Reasons of respiratory failure (group 55 pts.)

- Acute exacerbation of COPD: 30 (55%)
- Asthma bronchiale: 7 (13%)
- Pneumonia: 7 (13%)
- Cardiac failure: 3 (5%)
- Pulmonary embolism (acute, subacute): 3 (5%)
- Diffuse lung parenchymal diseases: 5 (9%)

### Reasons of respiratory failure (subgroup 34 pts.)

- Acute exacerbation of COPD: 18 (21%)
- Asthma bronchiale: 7 (6%)
- Pneumonia: 3 (6%)
- Cardiac failure: 2 (6%)
- Pulmonary embolism (acute, subacute): 2 (6%)
- Diffuse lung parenchymal diseases: 2 (9%)
### Differences between BiPAP and HFJV in survived patients

<table>
<thead>
<tr>
<th></th>
<th>BiPAP survived</th>
<th>HFJV survived</th>
<th>p BiPAP / HFJV ANOVA</th>
<th>p BiPAP / HFJV Mann-Whitney</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of pts.</td>
<td>10</td>
<td>12</td>
<td></td>
<td>NS</td>
</tr>
<tr>
<td>Age (years) Mean ± SD</td>
<td>59.30 ± 6.90</td>
<td>63.33 ± 7.98</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>pH *</td>
<td>7.316 ± 0.027</td>
<td>7.338 ± 0.014</td>
<td>0.0293</td>
<td></td>
</tr>
<tr>
<td>PaO₂ * (kPa)</td>
<td>5.74 ± 0.76</td>
<td>6.05 ± 0.79</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>CRP * (mg/l)</td>
<td>64.82 ± 38.52</td>
<td>41.35 ± 30.34</td>
<td>NS</td>
<td></td>
</tr>
</tbody>
</table>

* Values at admission in mean ± SD
Differences between BiPAP and HFJV in patients who died

<table>
<thead>
<tr>
<th></th>
<th>BiPAP died</th>
<th>HFJV dead</th>
<th>p  BiPAP / HFJV ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>66.86 ± 6.81</td>
<td>76.60 ± 11.59</td>
<td>NS</td>
</tr>
<tr>
<td>Mean ± SD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH *</td>
<td>7.237 ± 0.040</td>
<td>7.276 ± 0.053</td>
<td>NS</td>
</tr>
<tr>
<td>PaO$_2$ *(kPa)</td>
<td>5.10 ± 0.50</td>
<td>5.49 ± 0.31</td>
<td>NS</td>
</tr>
<tr>
<td>CRP *(mg/l)</td>
<td>74.86 ± 25.70</td>
<td>83.96 ± 25.58</td>
<td>NS</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>BiPAP died</th>
<th>HFJV died</th>
<th>p  BiPAP / HFJV Mann-Whitney</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>2</td>
<td>1</td>
<td>NS</td>
</tr>
<tr>
<td>Respiratory failure **</td>
<td>4</td>
<td>3</td>
<td>NS</td>
</tr>
<tr>
<td>MODS **</td>
<td>3</td>
<td>2</td>
<td>NS</td>
</tr>
</tbody>
</table>

* Values are in in mean ± SD at admission
** As the reason od death
MODS = Multiple Organ Dysfunction Syndrome
BiPAP - Regression analysis – probability of successful weaning from MV - 1

<table>
<thead>
<tr>
<th>Probability of successful weaning</th>
<th>Parameter</th>
<th>p</th>
<th>R</th>
<th>$R^2$ model</th>
<th>$R^2$ adjusted</th>
<th>CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>↓ Age</td>
<td>0.0499</td>
<td>-0.4764</td>
<td>22.79%</td>
<td>30.35%</td>
<td>95%</td>
<td></td>
</tr>
</tbody>
</table>

Dependency of successful weaning on age

$R^2 = 0.2279$

$R^2 = 0.3035$

The dependency of successful weaning on age can be represented by the following polynomial equation:

Polynomial (successful weaning): $p = 0.0499 R = -0.4764$

Adjusted Polynomial (successful weaning): $p = 0.0499 R = -0.4764$
BiPAP - Regression analysis – probability of successful weaning from MV - 2

<table>
<thead>
<tr>
<th>Parameter</th>
<th>p</th>
<th>R</th>
<th>$R^2$</th>
<th>$R^2$ adjusted</th>
<th>CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value at admission pH</td>
<td>0.0077</td>
<td>0.7641</td>
<td>64.46%</td>
<td>75.41%</td>
<td>95%</td>
</tr>
</tbody>
</table>

Dependency of successful weaning on pH value

\[
R^2 = 0.6446
\]

\[
R^2 = 0.7541
\]

$p = 0.0077$

$R = 0.7641$
HFJV - Regression analysis – probability of successful weaning from MV

<table>
<thead>
<tr>
<th>Probability of successful weaning</th>
<th>Parameter</th>
<th>p</th>
<th>R</th>
<th>R² model</th>
<th>R² adjusted</th>
<th>CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>↓</td>
<td>CRP</td>
<td>0.0149</td>
<td>-0.5560</td>
<td>31.29%</td>
<td>63.39%</td>
<td>95%</td>
</tr>
</tbody>
</table>

Dependency of successful weaning on CRP value

- \( R^2 = 0.3129 \)
- \( R^2 = 0.6339 \)

<table>
<thead>
<tr>
<th>CRP (mg/ml)</th>
<th>probability of successful weaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>100%</td>
</tr>
<tr>
<td>50</td>
<td>80%</td>
</tr>
<tr>
<td>100</td>
<td>60%</td>
</tr>
<tr>
<td>150</td>
<td>40%</td>
</tr>
</tbody>
</table>

\( p = 0.0140 \)
\( R = -0.5560 \)
Comparison of BiPAP and HFJV (Length of hospitalization, length of NIV and day of extubation are only in 22 successfully weaned patients)

<table>
<thead>
<tr>
<th></th>
<th>BiPAP (B)</th>
<th>HFJV (H)</th>
<th>p – B / H ANOVA</th>
<th>p – B / H Mann-Whitney</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Survived patients</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number</td>
<td>10</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average ± SD</td>
<td>(58.82%)</td>
<td>(70.59%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Dead patients</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number</td>
<td>7</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average ± SD</td>
<td>(41.18%)</td>
<td>(29.41%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Length of hospitalization</strong></td>
<td>15.90 ± 3.78</td>
<td>14.08 ± 3.30</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td><strong>Day of extubation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Length of NIV after extubation</strong></td>
<td>3.80 ± 0.60</td>
<td>4.00 ± 1.29</td>
<td>NS</td>
<td></td>
</tr>
</tbody>
</table>

* Values are in days mean ± SD
DISCUSSION

• It was shown that noninvasive ventilation improves the results of weaning patients from mechanical ventilation.
• Literature reports about frequency of weaning failure from 25.50% (Esteban) to 42.40% (Vallverdu).
• Authors applied two methods NIV in weaning from mechanical ventilation: BiPAP and an unusual mode - HFJV.
• Applying HFJV in weaning was effective in 70.59%.
• Applying BiPAP in weaning was effective in 58.82%.
• Weaning failure:
  29.41% in HFJV subgroup
  41.18% in BiPAP subgroup
• When comparing two methods of NIV in weaning, we found that HFJV: shorter length of hospitalization but there is a longer need of application after extubation.
Factors, which can worsen weaning from mechanical ventilation

- Instable cardiovascular status (circulatory support is needed)
- Nutrition (obesity or malnutrition)
- Metabolic disturbances (e.g. hyperglycaemia)
- Treatment with corticosteroids
- Ventilator induced diaphragm dysfunction
- Anaemia
- Delirium
- Anxiety, depression
Conclusion

Both methods of NIV: (BiPAP and HFJV) were successful in the weaning from MV.

HFJV mode was slightly more effective, the differences were not statistically significant.
References


