Muscle Strength and Endurance as Possible Predictors of Successful Extubation in Mechanically Ventilated Patients: A Pilot Study

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October 2017
Introduction

• Prolonged mechanical ventilation
  • Critical Illness myopathy / polyneuropathy
  • Respiratory muscle weakness
  • Economical burden
  • Decrease Quality Of Life

• Weaning from mechanical ventilation
  • Spontaneous Breathing Trial (SBT)
  • 10% - 20% failure
Introduction

• Failed extubation
  • 20% - 50% mortality rate
  • Increase length of hospital stay
  • Increase cost

• Other predictors
  • Respiratory rate, Tidal volume, Maximum inspiratory pressure, Maximum expiratory pressure, Rapid shallow breathing index, Cough strength, PaO$_2$/FiO$_2$ ratio

• No single test predicts extubation outcome
• Previous study show association between peripheral muscle strength and respiratory muscle strength
• No study explored the association between muscle strength, endurance and extubation readiness
Research Question

Can muscle strength and endurance be used as possible predictors of successful extubation in mechanically ventilated patients?
Aim

To determine if muscle strength and endurance of Deltoid, Sternocleidomastoid and Trapezius muscles are possible predictors of successful extubation in mechanically ventilated patients
Methodology

• Observational cross-sectional pilot study
• Steve Biko Academic Hospital
  • Surgery Intensive Care Unit (SICU)
  • Medical Intensive Care Unit (MICU)
  • 37 patients recruited
  • August 2015 – December 2015
• Ethical approval from Research Ethics Committee:
  - University of Pretoria
## Inclusion and Exclusion Criteria

<table>
<thead>
<tr>
<th>Excluded patients: n = 7</th>
<th>Included patients: n= 30</th>
</tr>
</thead>
<tbody>
<tr>
<td>• RASS &gt; 2+; RASS &lt; 2-</td>
<td>• &lt; 18 years</td>
</tr>
<tr>
<td>• Upper airway obstruction</td>
<td>• &lt; 3 days mechanically ventilated</td>
</tr>
<tr>
<td>• BMI &gt; 35 kg/m²</td>
<td>• Afrikaans and / or English</td>
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<tr>
<td>• Cardiomyopathy</td>
<td>• Heart rate &lt; 140 b/min</td>
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<tr>
<td>• Atrial fibrillation</td>
<td>• Systolic Blood pressure &gt; 90 mmHg</td>
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<tr>
<td>• Primary / previously diagnosed neuromuscular disorder</td>
<td>• Haemoglobin &gt; 7 g/dl⁻¹</td>
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<tr>
<td>• Psychiatric disorder</td>
<td>• Temperature &lt; 38.5 °C</td>
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<tr>
<td>• Acute asthma attack</td>
<td>• Ventilated CPAP: PEEP &lt; 8 cmH₂O, FiO₂ &lt; 40%, SaO₂ &gt; 90%, pH &gt; 7.35, PaO₂/FiO₂ &gt; 150</td>
</tr>
<tr>
<td>• Unable to perform manual muscle test due to a SCI, amputation, fractures, soft tissue injuries, burns or dressings limiting the testing of the muscle strength</td>
<td></td>
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</tbody>
</table>
Study Process

Determine level of consciousness:
CAM-ICU, RASS, Five point Questionnaire: RASS “-1”, “0”, “+1” and 3/5 questions included

RSBI, PaO₂/FiO₂ ratio documented

Evaluate pain experienced with NRS

Measure muscle endurance of upper limbs with MOTOMed® letto2 cycle ergometer:
Servo Cycle program, 5 minutes, 1 gear

Measure Deltoid, Sternocleidomastoid and Trapezius muscle strength with Oxford grading scale

Measure MIP and MEP with ventilators

Feedback to patient and attending physician
SBT after 30 minutes
Follow up 24 – 48 hours
MOTOMed® letto2 cycle ergometer
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Results

- Patients ventilated > 3 days
- Grade 3 muscle strength of Sternocleidomastoid and Deltoid muscles respectively had a 100% chance of successful extubation ($p = 0.038$).
- Trapezius muscle strength ($p = 0.366$) was not associated with successful extubation.

<table>
<thead>
<tr>
<th>Muscles tested</th>
<th>Successful extubation (n=23) %</th>
<th>Failed extubation (n=7) %</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Deltoid Left</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Grade 1</td>
<td>2 (50.0%)</td>
<td>2 (50.0%)</td>
<td>0.040</td>
</tr>
<tr>
<td>Grade 2</td>
<td>9 (64.3%)</td>
<td>5 (35.7%)</td>
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<tr>
<td>Grade 3</td>
<td>12 (100.0%)</td>
<td>0 (0.0%)</td>
<td></td>
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<tr>
<td><strong>Deltoid Right</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade 0</td>
<td>0 (0.0%)</td>
<td>1 (100.0%)</td>
<td>0.013</td>
</tr>
<tr>
<td>Grade 1</td>
<td>2 (40.0%)</td>
<td>3 (60.0%)</td>
<td></td>
</tr>
<tr>
<td>Grade 2</td>
<td>9 (75.0%)</td>
<td>3 (25.0%)</td>
<td></td>
</tr>
<tr>
<td>Grade 3</td>
<td>12 (100.0%)</td>
<td>0 (0.0%)</td>
<td></td>
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<tr>
<td><strong>Sternocleidomastoid Left</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade 0</td>
<td>0 (0.0%)</td>
<td>1 (100.0%)</td>
<td>0.038</td>
</tr>
<tr>
<td>Grade 1</td>
<td>2 (50.0%)</td>
<td>2 (50.0%)</td>
<td></td>
</tr>
<tr>
<td>Grade 2</td>
<td>10 (71.4%)</td>
<td>4 (28.6%)</td>
<td></td>
</tr>
<tr>
<td>Grade 3</td>
<td>11 (100.0%)</td>
<td>0 (0.0%)</td>
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</table>
Results

- Patients unable to ride the MOTOmed® letto2 cycle ergometer actively with the upper limbs for 4.5 minutes and covering a distance of 0.5 km demonstrated a linear trend ($p = 0.006$) to fail extubation.

<table>
<thead>
<tr>
<th></th>
<th>Total patients (n=30)</th>
<th>Successful extubation (n=23)</th>
<th>Failed extubation (n=7)</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active distance (km)</td>
<td>0.3 (0.0;0.8)</td>
<td>0.5 (&lt;0.1;0.9)</td>
<td>0.0 (0.0;&lt;0.1)</td>
<td>0.006</td>
</tr>
<tr>
<td>Passive distance (km)</td>
<td>0.2 (0.0;0.5)</td>
<td>&lt;0.1 (0.0;0.5)</td>
<td>0.5 (0.5;0.5)</td>
<td>0.01</td>
</tr>
<tr>
<td>Total distance (km)</td>
<td>0.5 (0.5;0.8)</td>
<td>0.6 (0.5;0.9)</td>
<td>0.5 (0.4;0.5)</td>
<td>0.001</td>
</tr>
<tr>
<td>Active time (min)</td>
<td>2.2 (&lt;0.1;4.6)</td>
<td>4.5 (0.1;5.0)</td>
<td>0.0 (0.0;0.1)</td>
<td>0.005</td>
</tr>
<tr>
<td>Passive time (min)</td>
<td>2.4 (&lt;0.1;4.6)</td>
<td>0.1 (0.0;4.5)</td>
<td>5.0 (4.5;5.0)</td>
<td>0.007</td>
</tr>
<tr>
<td>Speed (rpm)</td>
<td>24.5 (7.5;32.2)</td>
<td>27.0 (16.0;38.0)</td>
<td>0.0 (0.0;9.0)</td>
<td>0.003</td>
</tr>
</tbody>
</table>
Limitations & Recommendations

• Only patients understanding Afrikaans / English
• Patient has to be awake and orientated to use manual muscle strength testing
• Small sample size
• Reliability testing of the MOTOmed® letto2 cycle ergometer
Conclusion

• Novelty to test peripheral muscles with combined nerve innervations as the respiratory muscles.
• Muscle strength and endurance never before used or evaluated as indicators of successful extubation.
• Muscle strength (Deltoid & Sternocleidomastoid) and endurance (Motomed® letto2 cycle ergometer) may be useful tools to predict the success of extubation.
Conclusion

- Extra predictor
- ↓ Extubation failure
- ↓ Length of stay
- ↓ Financial expenditures
- ↑ QOL

First in ICU Protocol
Acknowledgements

• Co-authors:
  • Prof. AJ van Rooijen, Prof. JP Pretorius, Prof. P Rheeder and Prof. F Paruk

• All staff of the participating intensive care units

• Patients who made this study possible – none of the individuals received financial compensation for their contribution to this study

• Two critical care clinical technologists (Ms. C van Heerden and Ms. M van Jaarsveld) for assisting with the MIP and MEP measurements

• Prof. K van der Meyden and Prof. G Tintinger for their support and guidance in the study
Questions
References


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