Keys to Effective Mobilization for Patients on Ventilators

Konrad Dias, PT, DPT, CCS¹,
Ann Fick, PT, DPT, MS, CCS¹,
Heidi Tymkew, PT, DPT, MHS, CCS²
¹Physical Therapy Program, Maryville University, St. Louis, MO
²Washington University, St. Louis, MO.

Advances in medical technology have evolved the nature of mechanical ventilation. As a doctoring profession in the 21st century it is imperative that clinicians acquire adequate knowledge of mechanical ventilation and understand relevant implications of ventilators in an effort to create a safe and effective plan for mobility. This 2 hour course highlights key considerations applicable to the physical therapist and the physical therapist assistant in managing patients on mechanical ventilation. The course aims to educate the clinician on the basics of mechanical ventilation, ventilator settings and various modes of ventilation. In addition, the course accentuates a variety of implications when managing patients on ventilators with an emphasis on the weaning process. This course will utilize case examples to assist the learner in problem solving and clinical decision making for mobilizing patients on ventilators.

Course Description
- Advances in medical technology have evolved the nature of mechanical ventilation. As a doctoring profession in the 21st century it is imperative that clinicians acquire adequate knowledge of mechanical ventilation and understand relevant implications of ventilators in an effort to create a safe and effective plan for mobility. This 2 hour course highlights key considerations applicable to the physical therapist and the physical therapist assistant in managing patients on mechanical ventilation. The course aims to educate the clinician on the basics of mechanical ventilation, ventilator settings and various modes of ventilation. In addition, the course accentuates a variety of implications when managing patients on ventilators with an emphasis on the weaning process. This course will utilize case examples to assist the learner in problem solving and clinical decision making for mobilizing patients on ventilators.

Course Objectives
- Identify differences between normal ventilation and mechanical ventilation.
- Discuss key variables related to mechanical ventilation including but not limited to PEEP, pressure support, tidal volume and minute ventilation.
- Describe the different modes of mechanical ventilation.
- Discuss various physical therapy clinical implications related to mechanical ventilation and the weaning process.
- Outline appropriate clinical decision making for mobilizing patients on different mechanical ventilation settings.

Overview
- What is mechanical ventilation?
- What are the indications for mechanical ventilation?
- How is normal ventilation different from mechanical ventilation?
- What are the different modes and settings involved with mechanical ventilation?
- Relate to clinical examples
- Literature on mobility for patients on ventilators
- Summary and Conclusions

Mechanical Ventilation
- 2 major functions of the lung:
  – Ventilation
  – Respiration
- Definition: Utilization of machines or devices to assist or replace spontaneous breaths during ventilation.

Indications for Mechanical Ventilation
- Hypoxic Respiratory Failure
  – Severe hypoxemia with PaO₂ < 50 mm Hg with supplemental oxygen.
- Hypercapnic Respiratory Failure
  – Hypoventilation
  – Impaired respiratory pump
  – Increased dead space
  – Increased CO₂ production
- Airway Protection
  – Protection against aspiration
  – Relieve upper airway obstruction

Intentions of Mechanical Ventilation

- Reverse oxygenation problems
- Improve ventilation problems
  - Reduce ventilatory muscle fatigue
  - Reduce the work of breathing
- Improve respiration
  - Support or manipulate pulmonary gas exchange

Relationship between Oxygen Saturation and Partial Pressure $O_2$

<table>
<thead>
<tr>
<th>$SpO_2$</th>
<th>$PaO_2$</th>
<th>Signs and Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>97-99</td>
<td>90-100</td>
<td>None</td>
</tr>
<tr>
<td>95</td>
<td>80</td>
<td>None</td>
</tr>
<tr>
<td>90</td>
<td>60</td>
<td>Tachycardia, tachypnea, restlessness</td>
</tr>
<tr>
<td>85</td>
<td>50</td>
<td>Incoordination, impaired judgment, labored respirations, confusion</td>
</tr>
<tr>
<td>80</td>
<td>45</td>
<td>As above</td>
</tr>
</tbody>
</table>

Physiology involved with the mechanics of breathing

- **Airway Resistance**: Inflation entails the inspiratory muscles overcome:
  - The tendency of the lung to recoil inward
  - Resistance to flow offered by the airway
- **Lung Distensibility/ Compliance**:
  - A change in volume for a given change in pressure.
  - Compliance = $\frac{\Delta \text{Volume}}{\Delta \text{Pressure}}$


Arterial Oxygenation

- The ability of arterial blood to carry oxygen
  - $PaO_2$, $PO_2$
    - Hyperoxemia
    - Hypoxemia/ hypoxia
- $SpO_2$
- $FiO_2$
- Supplemental oxygen


Normal ventilation vs. Mechanical Ventilation

- **Negative Pressure Ventilation**
  - Pressure lower than the atmosphere allows inspiration to occur.
  - Former Iron lung
- **Positive Pressure Ventilation**
  - Pressure higher than atmospheric pressure is provided to the intraalveolar space during inspiration.
  - Current mechanical ventilator devices

2 Types of Positive Pressure Ventilation

- **Non Invasive Positive Ventilation (NPPV)**
- **Invasive Positive Pressure Ventilation**
**Non Invasive Positive Pressure Ventilation (NPPV)**

- Benefits of NPPV
- Types of masks
  - Nasal masks
  - Face masks
- Types of NPPV
  - CPAP
  - BiPAP

**Modes of Mechanical Ventilation**

- 3 important aspects of mechanical ventilation
  - What triggers the ventilator?
  - What aspect of inspiration is controlled by the ventilator?
  - What aspect terminates the delivery of inspiration?

- Most commonly used ventilator modes

**What aspect of inspiration is controlled by the ventilator?**

- Pressure controlled: Pressure delivered during inspiration is constant regardless of airway resistance or compliance.
  - Pressure is controlled to provide tidal volume of 6-8 ml/kg body weight.
- Flow controlled (Volume Controlled): Flow is controlled as a function of the preset tidal volume.

**What aspect terminates inspiration?**

- Volume cycled ventilation: Ventilator ceases inspiration following delivery of a preset volume of inspiration.
- Flow cycled ventilation: Ventilator stops inspiration when flow drops below a preset threshold, usually 25% of the peak flow.

**What triggers the ventilator?**

- No Spontaneous Breaths
  - Time is the trigger
    - Provides RR 14-20 bpm
- Presence of Spontaneous Breaths
  - Negative Pressure as the Trigger
    - Triggers inspiration when a threshold negative pressure of 0.5 to 2 cm H2O is detected.
  - Flow as the Trigger
    - Triggers inspiration when a threshold flow rate of 2-3 L/min is detected.

**Important terminology and parameters to monitor on the ventilator**

- FiO2
- Respiratory Rate (RR)
- Tidal volume (TV)
- Minute ventilation ($V_E$)
  - $V_E = TV \times RR$
- Pressure support
- Positive End Expiratory Pressure (PEEP)

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Invasive Mechanical Ventilation Modes
- Assist Control
- Synchronized intermittent mandatory ventilation (SIMV)
- Pressure Support Ventilation
- Continuous Positive Airway Pressure

Pressure Support Ventilation
- Weaning mode
  - Ventilator works only with spontaneous breaths.
  - For spontaneous breaths, a preset positive pressure is delivered.
  - Volume is not preset, pressure support augments the TV.
  - Patient controls RR and inspiratory time.
  - Advantages: Decreases the work of breathing.
  - Disadvantages: No guaranteed minute ventilation

Assist Control
- Non weaning mode
- Ventilator delivers a minimum minute ventilation by setting the TV and RR.
- With spontaneous breaths – ventilator delivers the preset TV.
- Advantages
- Disadvantages:
  - Periods of high respiratory rate patient can develop hyperinflation. Barotrauma, pneumothorax or auto PEEP (severe decrease in venous return).

CPAP
- Weaning mode
  - Provides continuous positive pressure within the airways.
  - Pressure support augments TV.

SIMV
- Weaning mode
  - Ventilator ensures a minimum minute ventilation by setting RR and TV.
  - Patient is able to breathe spontaneously between ventilator breaths.
  - For spontaneous breaths, VT is variable depending on the patient’s inspiratory effort.
  - Advantages – Exercises respiratory muscles
  - Disadvantages – Increase the work of breathing

Clinical Implications
- Modes and settings
- Weaning times and PT/OT
- Level of Sedation
- Passy Muir Speaking Valve
- Portable ventilators and ambulation
- Ambulation with an Ambu Bag
- Bronchopulmonary hygiene
- Suctioning

Ventilation and Neuromuscular Syndrome
Ventilation during acute illness often requires sedation, analgesia or neuromuscular blockade.
These interventions lead to neurocognitive impairment, physical debility, ICU acquired weakness and increases health care resource utilization.
PT can play a role in assisting with these impairments.

Muscle Loss in Critical Illness
Healthy well nourished individuals demonstrate muscle atrophy if immobilized for more than 72 hours. (Kartebein, JAMA 2007)
Older adults exhibit greater loss of muscle mass and strength compared to younger individuals with prolonged bed rest. (Lannuzzi-Sucich M. J Gerontol A Biol Sci Med, 2002).
Early initiation of PT in mechanically ventilated patients improves function and allows for a more rapid return to ambulation.

Effectiveness of PT in Critical Patients (Schweickert et al Lancet 2009)
Objective: To assess efficacy of combining daily interruption of sedation with PT and OT on functional outcomes in mechanically ventilated patients.
- Subjects: 104 mechanically ventilated patients in ICU at 2 university hospitals.
- Design: Randomized clinical trial
- Patients randomized to receive either early exercise and mobilization during periods of interruption of sedation or daily interruption of sedation with standard therapy care.
Results: Early administration of PT and OT along with interruption of sedation in critical illness is safe, effective and improves overall functional independence.

Early activity in Patients with Respiratory Failure (Baily et al. Crit Care Med 2007)
Purpose: To determine whether early activity is safe and feasible in ventilated patients with respiratory failure.
Design: Prospective cohort study
Setting: Eight bed respiratory ICU. Patients mechanically ventilated >4 days.
Interventions: Recorded activity events and adverse events.
- Activity: Sit on bed, sit in chair and ambulate
- Adverse: Fall to knees, feeding tube removal, SBP> 200 or <90, SP02 < 80% and extubation.
Results: 1449 activity events conducted in 6 month period.
- 233 (16%) sit in bed, 454 (31%) sit in chair and 762 (53%) ambulate
- 69% ambulated >100 feet at discharge
- <1% adverse events
Conclusion: Activity is safe and feasible in resp failure.

Early ICU mobility in Respiratory Failure (Morris et al. Crit Care Med. 2008)
Purpose: To determine the benefits of early PT in the ICU.
Design: Prospective cohort study in MICU.
Methods: Assessment of whether a mobility protocol increased the proportion of ICU patients receiving PT vs usual care.
Patients: Mechanically ventilated Protocol n=165, Usual care n=165
Results:
- Patients received at least 1 PT session (80% protocol v. 47% usual care)
- Protocol patients OOB earlier 5 vs 11 days.; p=0.01
- Protocol patients LOS in ICU 5.5 vs. 6.9 (p=0.025)
- Protocol patients Hospital LOS 11.2 vs. 14.5 days (p=0.06)
- No adverse events noted.

References