Christiane Perme, PT CCS

MECHANICAL VENTILATION: 
THE INSPIRATIONS, EXPIRATIONS, AND FRUSTRATIONS 
OF PHYSICAL THERAPISTS

Christiane Perme, PT CCS
Senior Physical Therapist
Houston Methodist Medical Center
Houston, TX-USA

DISCLOSURES

• I have no potential financial interests to report
• Every patient picture in this presentation has a written consent from the patient and/or family

Objectives

• Discuss the indications for mechanical ventilation
• List the three most common modes of mechanical ventilation
• Identify ventilator settings on the ventilator screen
• Synthesize information when mobilizing patients in ICU

Why am I here talking about mechanical ventilation today?

Because I want you to:
• Understand how important it is to know about mechanical ventilation when caring for patients who are critically ill
• Be better prepared to work with patients on mechanical ventilation
• Know that the information in this lecture can make a great impact on the physical therapy care provided to patients in ICU

EARLY MOBILITY IN ICU: EVIDENCE-BASED PRACTICE

• Mobilizing patients in ICU is safe, feasible and improves physical function!
  • It can reduce length of hospital stay and costs!
  • It can decrease incidence of Delirium!

—Schweickert WD. Lancet. 2009 May; 373:1874-1882

Christiane Perme, PT CCS
chrisperme@gmail.com
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WHAT DO PHYSICAL THERAPISTS NEED TO KNOW WHEN WORKING WITH PATIENTS ON VENTILATORS?

Basic understanding of:
- Cardiopulmonary physiology
- Pathophysiology of pulmonary disease
- Oxygenation, ventilation, blood gases
- Work of breathing
- Indications/complications of mechanical ventilation
- Artificial airways
- Modes of ventilation
- Weaning process

CLINICAL GOALS OF MECHANICAL VENTILATION

• To provide mechanical ventilatory support in order to meet physiologic needs until pulmonary system has recovered

INDICATIONS FOR MECHANICAL VENTILATION

- Acute respiratory failure indicated by failure of the respiratory system to maintain an adequate balance of pH, PaO2, and/or PaCO2
- Protection of the airway and lung parenchyma (drug overdose, CVA, head injury)
- Relief of upper airway obstruction (tumor, allergic reaction, edema)
- Improvement of pulmonary toilet in patients with excessive secretions or inability to successfully clear secretions by coughing

COMPLICATIONS OF MECHANICAL VENTILATION

- Oxygen toxicity
  • Proportional to the duration of time that the patient is exposed to FiO2 > 0.6
- Barotrauma
  • Pneumothorax and acute lung injury
- Decreased cardiac output
- Complications related to endotracheal tube
  • Hard and soft palate injuries, laryngeal dysfunction, tracheal stenosis, tracheomalacia, and near-fatal or fatal obstruction.
- Ventilator associated pneumonia
  • ~1% per day and has an associated mortality rate as high as 20–50%.
VENTILATOR CLASSIFICATION

• Negative pressure

• Positive pressure
  • Volume
  • Pressure

POSITIVE PRESSURE VENTILATORS

PURITAN BENNET™ 840

AVEA

HAMILTON-G5

POSITIVE PRESSURE VENTILATORS

SERVO

DRAGER

BiPap® Vision®

PORTABLE/TRANSPORT VENTILATORS

iVent 101

LTV® series 1200

HAMILTON-c2

AMBU BAG

• An Ambu bag is a proprietary brand of a self-inflating bag-valve-mask (BVM) resuscitator, used to provide artificial ventilation

ARTIFICIAL AIRWAYS

• Endotracheal tube (ETT)
  • Oral
  • Nasal
  • Tracheostomy (Trach)
RESULTS

- 1,449 activity events in 103 patients
  - Sit on bed: 233 (16%)
  - Sit in chair: 454 (31%)
  - Ambulate: 762 (53%)
- Patients with an endotracheal tube (ETT) in place:
  - 593 activity events
  - 249 were ambulation (42%)
- There was < 1% activity-related adverse events
- No patient was extubated during activity

TERMINOLOGY

- A/C: Assist-control
- SIMV: Synchronized Intermittent Mandatory Ventilation
- CPAP: Continuous Positive Airway Pressure
- PSV: Pressure Support Ventilation
- PEEP: Positive End Expiratory Pressure
- NIPPV: Noninvasive Positive Pressure Ventilation
- FiO2: Fraction of Inspired Oxygen
- Minute ventilation = RR x tidal volume

VENTILATOR SETTINGS

- Mode of ventilation: Determines how the ventilator initiates a breath, how the breath is delivered, and when the breath is terminated
- FiO2: The FiO2 value is always expressed as a decimal, not a percentage. An FiO2 of 1.0 can also be expressed as 100% oxygen
- PEEP: Pressure remaining in the lungs at end expiration

Early activity is feasible and safe in respiratory failure patients
Bailey P, et al.
Critical Care Medicine 2007. Vol. 35 Number 1. 139-145

- Activity events:
  - Sit on bed
  - Sit in chair
  - Ambulate
- Activity related adverse events:
  - Fall to knees
  - Tube removal
  - Systolic blood pressure > 200 mmHg
  - Systolic blood pressure < 90 mmHg
  - Oxygen desaturation < 80%
  - Extubation

• Upper screen: Patient’s ventilatory status
  - RR
  - Tidal Volume
  - Minute Volume

• Lower screen: Ventilator settings
  - Mode of ventilation
  - Rate
  - Oxygen
  - PEEP
  - Alarm settings
MODES OF MECHANICAL VENTILATION

**Assisted:**
- CMV/AC
- IMV/SIMV

**Spontaneous:**
- CPAP
- Pressure support

*Ventilator:*
- Does the work
- Starts and stops the breath

*Patient:*
- Does the work
- Starts and stops the breath

OTHER MODES OF MECHANICAL VENTILATION

- Pressure Regulated Volume Control (PRVC)
- Pressure Control Ventilation (PCV)
- Pressure Control-Inverse Ratio Ventilation (PC-IRV)
- Airway Pressure Release Ventilation (APRV)
- Bi-Level Ventilation
- Dual-PAP Ventilation
- High-frequency oscillatory ventilation (HFOV)
- High-frequency jet ventilation (HFJV)
- Adaptive Support Ventilation (ASV) – Hamilton ventilator
- Proportional Pressure Support (PPS) – Draeger ventilator
- Tube Compensation (TC)

VENTILATION MODES

- A/C
- SIMV
- SPONTANEOUS/CPAP/PS

Respiratory cycle in mechanical ventilation

- Phase 1 - Beginning of inhalation (Triggering mechanism):
  - Pressure triggered
  - Flow triggered
  - Time triggered
  - Volume triggered
- Phase 2 - End inspiration (Cycling method):
  - Pressure cycled
  - Flow cycled
  - Time cycled
  - Volume cycled
- Phase 3 and 4 - End of exhalation and beginning of inspiratory phase

ASSIST-CONTROL

- Non weaning mode
- Rate and tidal volume are set to deliver a minimum minute ventilation
- Patient can generate as many breaths as needed by triggering the ventilator
- On each spontaneous respiratory effort generated by the patient, the machine delivers the preset tidal volume
- Patients usually tolerate increased demands during physical therapy if medically stable

Christiane Perme, PT CCS
chrisperme@gmail.com
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SIMV

- Weaning mode
- Rate and tidal volume are set to deliver a minimum minute ventilation
- Patient is able to breath spontaneously between ventilator breaths
- On each spontaneous breath, the patient will receive as much volume as he can generate
- Often used with in conjunction with PSV

CPAP

- Spontaneous mode of ventilation
- Weaning mode
- CPAP maintains positive pressure continuously in the airways
- Pressure support is be added to augment patient's tidal volume

PRESSURE SUPPORT

- Applies to spontaneous breaths only
- May be applied to a patient’s spontaneous breathing during SIMV or CPAP.
- Once the patient triggers the ventilator, the preset positive pressure is delivered
- Volume is not pre-set, Pressure Support augments the tidal volume
- The patient controls respiratory rate and inspiratory time.
- Usually set at 10 cmH2O
- Highest - Lowest PS ????
  - 5-30 cmH2O

<table>
<thead>
<tr>
<th>Mode</th>
<th>Rate</th>
<th>Tidal volume</th>
<th>Additional Breaths</th>
<th>Minute Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>A/C</td>
<td>10</td>
<td>500 ml</td>
<td>Yes *Always 500 ml</td>
<td>At least 5 L/m</td>
</tr>
<tr>
<td>SIMV</td>
<td>10</td>
<td>500 ml</td>
<td>Yes **Whatever Pt can generate</td>
<td>At least 5 L/m</td>
</tr>
<tr>
<td>SPONT/CPAP/PS</td>
<td>No</td>
<td>No</td>
<td>Pt determines resp. rate</td>
<td>????</td>
</tr>
</tbody>
</table>
PEEP

- Pressure remaining in the lungs at end expiration
- PEEP improves oxygenation allowing for lower levels of oxygen
- PEEP increases Functional Residual capacity (FRC)
  - FRC = ERV + RV
- Used to prevent airways from collapsing
- Excessive PEEP may reduce cardiac output and impair systemic oxygen delivery
- In non-ventilated patient with normal lungs, 3 to 5 cm H₂O of PEEP is considered physiologically normal

Ranges for PEEP

<table>
<thead>
<tr>
<th>Level</th>
<th>Purpose</th>
</tr>
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| Low PEEP    | Physiologic  
(3 - 5 cmH₂O)  
- Used to preserve patient’s normal FRC |
| Moderate PEEP | Used to treat refractory hypoxemia  
(5 - 15 cmH₂O)  
- Most common range used for acute lung injury |
| High PEEP   | Used only for severe lung injury  
(> 15 cmH₂O) |

VENTILATOR ALARMS

- RESPIRATORY RATE ALARM
  - High rate
  - Low rate
- PRESSURE ALARM
  - High pressure
  - Low pressure
- VOLUME ALARM
  - Low minute volume
  - High minute volume
- APNEA ALARM
- Back-up ventilation
- LOW GAS SOURCE
- POWER LOSS

PREDICTORS OF WEANING SUCCESS

- Conscious and alert state
- Hemodynamic and cardiopulmonary stability
- Intact respiratory drive
- PaO₂ > 60 mmHg, PEEP < 5 cmH₂O, FIO₂ < 40%
- Stable renal function
- Ability to protect airways and clear secretions
- Adequate and stable hemoglobin
- No need for sedatives agents or alert on a stable dose of sedatives
- Afebrile or febrile and hemodynamically stable
- Acceptable ABG’s and CXR
NON-INVASIVE POSITIVE PRESSURE VENTILATION (NIPPV)

- Uses a mask instead of an artificial airway
- Used when short term ventilation is expected:
  - Prevent intubation
  - Failed extubation
- Two common forms of NIPPV:
  - CPAP
  - BiPAP
- NIPPV Masks:
  - Face mask
  - Full face mask
  - Nasal mask
  - Nasal pillow
- Some patients may need it prn and others may NOT tolerate being removed from it!!!

TAKE HOME MESSAGE

- Always assess risk versus benefits!!!
- Always consider the work of breathing during physical therapy activities
- Make sure adequate staff back up is available in case of an emergency!!!

TAKE HOME MESSAGE

- It is ALWAYS important to know a few things prior to starting a physical therapy session:
  - Reason why patient requires mechanical ventilation
  - Ventilator settings
  - Respiratory rate
  - Oxygen saturation
- This will help you determine how well patient is tolerating therapy session.....

CAN YOU IDENTIFY?

- Mode of ventilation
- Rate
- Oxygen
- PEEP
- Respiratory rate
- Alarms

REFERENCES


THANK YOU!

Christiane Perme, PT CCS
chrisperme@gmail.com