Mechanical Ventilator

Soliman Ahmed, RN, BSc
GM Arab Palliative Care Academy
CEO Jordan Palliative care society
The nurse must be able to do the following:

1. Identify the indications for mechanical ventilation.
2. List the steps in preparing a patient for intubation.
3. Determine the Parameter of MV.
4. Describe the various modes of ventilation and their implications.
5. Describe at least two complications associated with patient’s response to mechanical ventilation and their signs and symptoms.
6. Describe the causes and nursing measures taken when trouble-shooting ventilator alarms.
7. Describe preventative measures aimed at preventing selected other complications related to endotracheal intubation.
8. Give rationale for selected nursing interventions in the plan of care for the ventilated patient.
9. Complete the care of the ventilated patient checklist.
Definition

**Ventilation**: Is the movement of a volume of gas into and out of the lungs.

**Respiration**: Is the exchange of oxygen and carbon dioxide across a membrane either in the lungs or at the cellular level.

**Pulmonary shunting**: Pathological condition which results when the alveoli of the lungs are perfused with blood as normal, but ventilation (the supply of air) fails to supply the perfused region.
Mechanical ventilator
Definition: Is the use of a mechanical device (machine) to inflate and deflate the lungs.

Purpose:
- To maintain or improve ventilation and tissue oxygenation.
- To decrease the work of breathing & improve patient’s comfort.
Indication

- Airway Protection
- Hypercapnia Respiratory Failure
- Hypoxemic Respiratory Failure
- Cardiovascular Distress
- Neuromuscular Disorders.
Criteria for intubation of ventilator:

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Ventilation indicated</th>
<th>Normal range</th>
</tr>
</thead>
<tbody>
<tr>
<td>A- Pulmonary function studies:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respiratory rate (breaths/min)</td>
<td>More than 35</td>
<td>12-20</td>
</tr>
<tr>
<td>Tidal volume (ml/kg)</td>
<td>Less than 5</td>
<td>5-7</td>
</tr>
<tr>
<td>Vital capacity (ml/kg)</td>
<td>Less than 15</td>
<td>65-75</td>
</tr>
<tr>
<td>B- Arterial blood Gases</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PH</td>
<td>Less than 7.25</td>
<td>7.35-7.45</td>
</tr>
<tr>
<td>PaO₂ (mmHg)</td>
<td>Less than 60</td>
<td>75-100</td>
</tr>
<tr>
<td>PaCO₂ (mmHg)</td>
<td>More than 50</td>
<td>35-45</td>
</tr>
</tbody>
</table>
# Intubation Equipment

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laryngoscope</td>
<td></td>
</tr>
<tr>
<td>Endotracheal (ET) tube</td>
<td></td>
</tr>
<tr>
<td>Stylet</td>
<td></td>
</tr>
<tr>
<td>Syringe, 10 mL (to inflate ET tube balloon)</td>
<td></td>
</tr>
<tr>
<td>Sterile gloves</td>
<td></td>
</tr>
<tr>
<td>Stethoscope</td>
<td></td>
</tr>
<tr>
<td>Suction catheter (eg, Yankauer)</td>
<td></td>
</tr>
<tr>
<td>Oral and nasal airways</td>
<td></td>
</tr>
<tr>
<td>Ambu bag and mask attached to oxygen source</td>
<td></td>
</tr>
<tr>
<td>Endotracheal attachment device (E-tad) or tape</td>
<td></td>
</tr>
<tr>
<td>Call for chest x-ray to confirm position of</td>
<td></td>
</tr>
<tr>
<td>endotracheal tube</td>
<td></td>
</tr>
</tbody>
</table>

- Call for chest x-ray to confirm position of endotracheal tube.
Component of MV machine

- Ventilator Circuit
- Air Filters
- Vent Mount/Catheter
- Flow Sensor
Ventilator Circuit

Air Filters
Vent Mount/Catheter

Flow Sensor
Types of Mechanical ventilators
Ventilators deliver gas to the patient under positive pressure, during the inspiratory phase.
Negative Pressure (Iron lungs.)

- The patient’s body was encased in an iron cylinder and negative pressure was generated.
The four stages of mechanical ventilation

**Trigger phase**
The initiation of an inhalation which is triggered by an effort from the patient or by set parameters by the mechanical ventilator.

**Inspiratory phase**
The inhalation of air into the patient.

**Cycling phase**
The moment when inhalation has ceased but before exhalation has begun.

**Expiratory phase**
The passive exhalation of air from the patient.
Types of Positive - pressure ventilators

Volume Ventilators
- Commonly used in critical care settings.
- Designated volume of air is delivered with each breath.
- RR, inspiratory time, and TV are selected for the mechanical breaths.

Pressure Ventilators
- Increasing used in critical care units.
- Delivers a selected gas pressure to the patient early in inspiration and sustains the pressure throughout the inspiratory phase.
- Exhaled tidal volume is the variable to monitor closely.
Classification of positive-pressure ventilators

According to how the inspiratory phase ends

**Volume cycled ventilator**
Inspiration is terminated after a preset tidal volume has been delivered

**Pressure cycled ventilator**
Inspiration is terminated when a specific airway pressure has been reached
Modes of Mechanical Ventilation

**Volume Mode**
- A/C assisted control
- SIMV synchronizes intermittent mandatory ventilation
- CMV control mandatory ventilation

**Pressure Mode**
- Pressure-support ventilation (PSV)
- Continuous positive airway pressure (CPAP)
- Positive end expiratory pressure (PEEP)
- Noninvasive bi level positive airway pressure ventilation (BiPAP)
Volume Modes

Assisted Control (A/C)

- Provides the patient with a pre-set tidal volume at a pre-set rate.
- Patient may initiate a breath on his own
- Ventilator assists by delivering a specified tidal volume to the patient.
- Client can breathe at a higher rate than the preset number of breaths/minute
- Total respiratory rate is determined by the number of spontaneous inspiration initiated by the patient plus the number of breaths set on the ventilator.
- Often used as initial mode of ventilation

Disadvantages: hyperventilation
Volume Modes

Synchronizes Intermittent Mandatory Ventilation (SIMV)

❖ Provides the patient with a pre-set number of breaths/minute at a specified tidal volume and FiO2.
❖ In between the ventilator-delivered breaths, the patient is able to breathe spontaneously at his own tidal volume and rate with no assistance from the ventilator.
❖ Any breaths taken above the set rate are spontaneous breaths taken through the ventilator circuit.
❖ Adding pressure support during spontaneous breaths can minimize the risk of increased work of breathing.
❖ Breaths are synchronized with the patient spontaneous breath.
❖ Used to wean the patient from the mechanical ventilator.
Volume Modes

Control mandatory ventilation (CMV)

- completely provided by the mechanical ventilator with a preset tidal volume, respiratory rate and oxygen concentration
- Ventilator totally controls the patient’s ventilation
- Client does not breathe spontaneously.
- Client cannot initiate breathe
## Volume Mode

### Assisted Control (A/C)
- Provides the patient with a pre-set tidal volume at a pre-set rate.
- Patient may initiate a breath on his own.
- Ventilator assists by delivering a specified tidal volume to the patient.
- Client can breathe at a higher rate than the preset number of breaths/minute.
- Total respiratory rate is determined by the number of spontaneous inspiration initiated by the patient plus the number of breaths set on the ventilator.
- Often used as initial mode of ventilation.
- Disadvantages: hyperventilation.

### Synchronizes Intermittent Mandatory Ventilation (SIMV)
- Provides the patient with a pre-set number of breaths/minute at a specified tidal volume and FiO2.
- In between the ventilator-delivered breaths, the patient is able to breathe spontaneously at his own tidal volume and rate with no assistance from the ventilator.
- Any breaths taken above the set rate are spontaneous breaths taken through the ventilator circuit.
- Adding pressure support during spontaneous breaths can minimize the risk of increased work of breathing.
- Breaths are synchronized with the patient spontaneous breath.
- Used to wean the patient from the mechanical ventilator.

### Control mandatory ventilation (CMV)
- Completely provided by the mechanical ventilator with a preset tidal volume, respiratory rate and oxygen concentration.
- Ventilator totally controls the patient’s ventilation.
- Client does not breathe spontaneously.
- Client cannot initiate breathe.
Pressure Modes

Pressure Support Ventilation (PSV)

- The patient breathes spontaneously while the ventilator applies a predetermined amount of positive pressure to the airways upon inspiration.
- Patient’s spontaneous breaths with positive pressure boost during inspiration
- Helps to overcome airway resistance and reducing the work of breathing
- Indicated for patients with small spontaneous tidal volume and difficult to wean patients.
- The inspired tidal volume and respiratory rate must be monitored closely to detect changes in lung compliance.
Pressure Modes

(Continued)

❖ Constant positive airway pressure during spontaneous breathing
❖ Positive pressure applied at the end of expiration (PEEP)
❖ CPAP can be used for intubated and non-intubated patients
❖ used as a weaning mode and for nocturnal ventilation
❖ Prevent atelectasis or collapse of alveoli
❖ Improve gas exchange & oxygenation
❖ Treat pulmonary edema (pressure helps expulsion of fluids from alveoli)
Pressure Modes

Noninvasive Bilateral Positive Airway Pressure Ventilation (BiPAP)

- noninvasive form of mechanical ventilation provided by means of a nasal mask or nasal prongs, or a full-face mask
- allows the clinician to select two levels of positive-pressure support (inspiration pressure + expiration pressure)
Common Parameter and Setting of MV
## Common Parameter and Setting of MV

<table>
<thead>
<tr>
<th>Fraction of inspired oxygen (FiO2)</th>
<th>The percent of oxygen concentration that the patient is receiving from the ventilator. (Between 21% - 100%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initially a patient is placed on a high level of FiO2 (60% or higher).</td>
</tr>
<tr>
<td></td>
<td>Subsequent changes in FiO2 are based on ABGs, PaO2 and the SaO2</td>
</tr>
<tr>
<td></td>
<td>An FiO2 of 100% for an extended period of time can be dangerous (oxygen toxicity) but it can protect against hypoxemia</td>
</tr>
</tbody>
</table>
Common Parameter and Setting of MV

- **Tidal Volume (VT)**
  - Volume of air delivered to a patient during a ventilator breath.
  - The amount of air inspired and expired with each breath.
  - The large tidal volumes may lead to (volutrauma) aggravate the damage inflicted on the lungs.
  - Tidal volume targets (5 to 8 mL/kg) are now recommended.
**Common Parameter and Setting of MV**

| Peak Flow/Flow Rate | - The speed of delivering air per unit of time, and is expressed in L/M  
|                     |   - The higher the flow rate inspiration, the shorter the inspiration  
|                     |   - The lower the flow rate, the longer the inspiration  |

| Peak pressure       | - In adults if the peak airway pressure is persistently above  
|                     |   45 cmH2O, the risk of barotrauma is increased  |
# Common Parameter and Setting of MV

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respiratory Rate</td>
<td>❖ The number of breaths the ventilator will deliver/minute (10-20 b/m).</td>
</tr>
<tr>
<td></td>
<td>❖ Total respiratory rate equals patient rate plus ventilator rate.</td>
</tr>
<tr>
<td></td>
<td>❖ In case acidosis increase RR to decrease CO2</td>
</tr>
<tr>
<td></td>
<td>❖ In case alkalosis decrease RR to increase CO2</td>
</tr>
<tr>
<td>Minute Volume (VE)</td>
<td>❖ Minute volume is the amount of gas inhaled or exhaled from a person's lungs in one minute.</td>
</tr>
<tr>
<td>I:E Ratio</td>
<td>❖ The ratio of inspiratory time to expiratory time during a breath (Usually = 1:2)</td>
</tr>
</tbody>
</table>
### Common Parameter and Setting of MV

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sigh</strong></td>
<td>A breath that has a greater volume than the tidal volume.</td>
</tr>
<tr>
<td></td>
<td>It provides hyperinflation and prevents atelectasis.</td>
</tr>
<tr>
<td><strong>Sensitivity (trigger)</strong></td>
<td>The sensitivity function controls the amount of patient effort</td>
</tr>
<tr>
<td><strong>Sensitivity</strong></td>
<td>needed to initiate an inspiration</td>
</tr>
</tbody>
</table>
Complications of Mechanical Ventilation
## Complications of Mechanical Ventilation

<table>
<thead>
<tr>
<th>Airway Complications</th>
<th>Artificial Airway Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>❖ Aspiration</td>
<td>❖ Complications related to Endotracheal Tube</td>
</tr>
<tr>
<td>❖ Decreased clearance of secretions</td>
<td>❖ Tube kinked or plugged</td>
</tr>
<tr>
<td>❖ Nosocomial or ventilator-acquired pneumonia</td>
<td>❖ Cuff failure</td>
</tr>
<tr>
<td></td>
<td>❖ Tracheal stenosis or tracheomalacia</td>
</tr>
<tr>
<td></td>
<td>❖ Laryngeal edema</td>
</tr>
</tbody>
</table>
## Complications of Mechanical Ventilation

<table>
<thead>
<tr>
<th>Mechanical complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Hypoventilation with atelectasis with respiratory acidosis or hypoxemia.</td>
</tr>
<tr>
<td>- Hyperventilation with hypocapnia and respiratory alkalosis</td>
</tr>
<tr>
<td>- Barotrauma</td>
</tr>
<tr>
<td>- Closed pneumothorax,</td>
</tr>
<tr>
<td>- Tension pneumothorax,</td>
</tr>
<tr>
<td>- Pneumomediastinum,</td>
</tr>
<tr>
<td>- Subcutaneous emphysema.</td>
</tr>
<tr>
<td>- Alarm “turned off”</td>
</tr>
<tr>
<td>- Failure of alarms or ventilator</td>
</tr>
<tr>
<td>- Inadequate nebulization or humidification</td>
</tr>
<tr>
<td>- Overheated inspired air, resulting in hyperthermia</td>
</tr>
</tbody>
</table>
Troubleshooting Ventilator Alarms
Troubleshooting Ventilator Alarms

Low exhaled volume

Causes
- Cuff leak
- Tubing disconnect
- Patient disconnected

Treatment
- Evaluate cuff; reinflate prn
- If ruptured, tube will need to be replaced.
- Evaluate connections; tighten or replace as needed
- Check ETT placement, reconnect to ventilator
High pressure:
- Secretions in airway
- Patient biting tubing
- Tube kinked
- Cuff herniation
- Increased airway resistance/decreased lung compliance

causes

treatment
- Suction patient
- Reposition patient’s head/neck
- Deflate and reinflate cuff
- Auscultate breath sounds
- Explain all procedures to patient in calm
- Sedate/medicate as necessary
- Stabilize tube
Troubleshooting Ventilator Alarms

Low pressure:

causes
- Oxygen malfunction

- Disconnect patient from ventilator
- manually with ambubag
- call R.T
Weaning

Used to describe the gradual process of decreasing ventilator support
Methods of Weaning

❖ T-piece trial

☐ Removing the patient from the ventilator and having him / her breathe spontaneously on a T-tube connected to oxygen source.

☐ Goal is to progressively increase the time spent off the ventilator.
Methods of Weaning

- **Continuous Positive Airway Pressure (CPAP) weaning**
  - gradually decreasing the number of breaths delivered by the ventilator to allow the patient to increase number of spontaneous breaths

- **Synchronized Intermittent Mandatory Ventilation (SIMV) weaning**
  - The patient does all the work of breathing without the aid of a backup rate or tidal volume.
Methods of Weaning

Pressure Support Ventilation (PSV) weaning
❖ using the PSV mode, the level of pressure support is gradually decreased based on the patient maintaining an adequate tidal volume and a respiratory rate
❖ PSV weaning is indicated: Difficult to wean patients, Small spontaneous tidal volume
Weaning Readiness Criteria

- Awake and alert
- Hemodynamically stable,
- Arterial blood gases (ABGs) normalized or at patient’s baseline
- Positive end-expiratory pressure (PEEP) ≤5 cm H2O
- Chest x-ray reviewed for correctable factors; treated as indicated
- Major electrolytes within normal range
- Hematocrit >25%
- Core temperature >36°C and <39°C
- Adequate management of pain/anxiety/agitation
- Adequate analgesia/ sedation (record scores on flow sheet)
Role of Nursing
Before weaning

❖ Ensure that indications for the implementation of Mechanical ventilation have improved
❖ Ensure that all factors that may interfere with successful weaning are corrected
❖ Assess readiness for weaning
❖ Ensure that the weaning criteria / parameters are met.
❖ Explain the process of weaning to the patient and offer reassurance to the patient.
❖ Initiate weaning in the morning when the patient is rested.
Before weaning

- Elevate the head of the bed & Place the patient upright
- Ensure a patent airway and suction if necessary, before a weaning trial,
- Ensure patient’s comfort & administer pharmacological agents for comfort, such as bronchodilators or sedatives as indicated.
- Help the patient through some of the discomfort and apprehension.
- Support and reassurance help the patient through the discomfort and apprehension as remains with the patient after initiation of the weaning process
- Evaluate and document the patient’s response to weaning
During Weaning

- Wean only during the day.
- Remain with the patient during initiation of weaning.
- Instruct the patient to relax and breathe normally.
- Monitor the respiratory rate, vital signs, ABGs, diaphoresis and use of accessory muscles frequently.
After Weaning

ENSURE THAT EXTUBATION CRITERIA ARE MET

DOCUMENTATION
Nursing Care of Patients on Mechanical Ventilation
Nursing Care of Patients on Mechanical Ventilation

1. Maintain airway patency & oxygenation
2. Promote comfort
3. Maintain fluid and electrolytes balance
4. Maintain nutritional state
5. Maintain urinary & bowel elimination
6. Maintain eye, mouth and cleanliness and integrity
7. Maintain mobility/musculoskeletal function
Nursing Care of Patients on Mechanical Ventilation

8. Maintain safety
9. Provide psychological support
10. Facilitate communication
11. Provide psychological support & information to family
12. Responding to ventilator alarms / Troubleshooting ventilator alarms
13. Prevent nosocomial infection
14. Documentation
THANK YOU FOR LISTENING

ANY QUESTION??