Mechanical Ventilation

Educational Reinforcement Material
Critical Care Fundamentals: Mechanical Ventilation

Outline

Mechanical Ventilation Basics: Part 1

A. 0055 Goals of Mechanical Ventilation
   a. 0110 1) Maximize patient comfort (MV settings, sedation)
   b. 0134 2) Decrease work of breathing/ allow spontaneous breathing
      i. One of the main reasons for mechanical ventilation is when your patient is having excessive work of breathing and they are either in respiratory failure or on the verge of respiratory failure.
      ii. Optimal type of breath is spontaneous breathing
   c. 0230 3) Provide adequate (not perfect) gas exchange (oxygenation and ventilation)
      i. Clearly define oxygen saturation goals
      ii. Clearly define CO₂ goals
         1. 02:53 Example: A patient with a traumatic brain injury would need a normal CO₂ goal because a high CO₂ would increase cerebral blood flow and thereby increase intracranial pressure.
   d. 0330 4) Minimize toxicity
      i. Barotrauma- overdistension
      ii. Volutrauma- high volumes
      iii. Atelectotrauma- opening and closing alveoli
      iv. O₂ toxicity- >60% (even for short periods of time)
      v. 04:15 Adverse effects on the cardiovascular system
   e. 0430 5) This is a supportive therapy to allow time for other interventions to treat the cause of respiratory failure

B. 0511 Basic Review: Respiratory Physiology
   a. 0515 Inhalation
      i. Functional Residual Capacity (FRC): Volume of gas in the lungs at end expiration, but prior to inhalation; a state of no gas exchange
         1. Natural tendency is for the lungs to want to collapse due to the natural elastic forces of the lung
         2. Natural tendency of the chest wall to want to expand outwards
      ii. 0545 Active process by diaphragmatic contraction into the abdomen and the rib cage to move outwards
         1. ↑ intra-thoracic volume
         2. ↓ intra-thoracic pressure
         3. ↑ Pressure gradient between atmosphere and intra-thoracic space
   b. 06:20 Exhalation
      i. Passive process
         1. Diaphragm relax
         2. Lung recoils
         3. ↑ intra-thoracic pressure
         4. Creates a pressure gradient (alveolar pressure exceeds atmospheric pressure) and gas flow proceeds out of the lungs
      ii. Active process: obstructive physiology (example: COPD and asthma) causes it to become active

C. 06.55 Positive Pressure Ventilation
   a. Spontaneous breathing occurs via a negative pressure circuit (pulled into the lungs)
   b. Mechanical ventilation is a complete reversal of normal physiological breathing and occurs via a positive pressure system (pushed into the lungs)
   c. Air flow into lungs is now the result of a machine (ventilator) pushing or forcing air into the lungs

D. 0748 Oxygenation
   a. Diffusion: oxygen moves down the concentration gradient, down the alveoli and into the capillaries
   b. 0803 FiO₂ – first way to improve oxygenation

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c. **0812** PEEP- second way to improve oxygenation (optimal PEEP)

d. **0826** Mean Airway Pressure average pressure your lung is being exposed to during mechanical ventilation- both inspiration and expiration

  i. **0844** I:E ratio (inspiration to expiration) – lungs stay in expiration twice as long as inspiration

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0910 Inspiratory time: can increase oxygenation, but is usually used for refractory hypoxemia; this increases the mean airway pressure -> improved oxygenation

  i. **0930** Allows air re-distribution from highly compliant alveoli to less compliant alveoli

  ii. **0944** Maintaining a larger surface area at end inspiration and allowing more time for air to diffuse across the alveoli and into the capillaries
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E. **1002** Ventilation= removal of CO₂ from the body

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a. Simple diffusion + Convection- CO₂ builds up in the capillaries

b. **1040** Minute Ventilation= Respiratory Rate x Tidal Volume

  i. **1058** Dead space ventilation- in theory people should breathe in gas that is void of CO₂; however, the CO₂ that remains in the airway mixes w/ the inhaled gas=> increased dead space ventilation with worsening respiratory distress/ decreased ventilation => decreased gradient for CO₂ to diffuse out of the capillaries

  ii. **1138**: inhalation of CO₂ “void” gas allows CO₂ to diffuse out of the capillaries and into the alveoli, which is removed with exhalation; if we breathe in a larger tidal volume, this will extend the alveoli, which increases the transfer of CO₂ or breath faster by increasing the respiratory rate

  iii. **1212** Tidal volume- limit to how much can deliver, goal 4-8 ml/kg of predicted body weight

  1. If give too much-> volutrauma

  iv. **1237** Respiratory Rate

  1. **1245**: Obstructive Lung Disease (e.g. COPD and Asthma)- want to decrease the respiratory rate to allow more time in exhalation because if the expiratory time is too short then the CO₂ is trapped
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F. **1352** Complications of Mechanical Ventilation

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a. **1406** Barotrauma: injury to alveoli, caused by excessive pressure from the ventilator

  i. **1607** Looking at the plateau pressure, a.k.a. the pressure that the alveoli see-> this is seen by doing an inspiratory pause

  ii. **1650**: limit the plateau pressure to < 30 mmHg

b. **1413** Volutrauma: over distension of alveoli from excessive tidal volume (Vt)

  i. **1656**: limit the tidal volumes to 4-8 ml/ kg of predicted body weight

c. **1416** Atelectotrauma: damage which may occur when repetitively opening and closing lung units (a type of sheering stress to the lung)

  i. **1705**: Importance of Optimal PEEP

  1. **1716** End Inspiration: well expanded and optimal to provide adequate gas exchange

  2. **1729**: Expiration with inadequate PEEP: the alveoli collapse and develop atelectasis; a lot more pressure will be needed to expand the alveoli from the collapsed state to the volume at end expiratory (sheer stress)

  3. **1803**: Expiration with adequate PEEP: less pressure is needed to re-expand the alveoli at end expiration (have not allowed the alveoli to close and become atelectatic)

  4. **1825**: Driving Pressure- difference between the plateau pressure and the PEEP
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d. **1438** Biotrauma: lung injury resulting from inflammation mediators (precipitated by VILI) this can be caused by barotrauma, volutrauma, or atelectotrauma

e. **1509** Oxygen Toxicity: lung injury due to O₂ induced production of free radicals

  i. Using a goal of <100% saturation allows weaning of FiO₂ and decrease risk of oxygen toxicity; goal of <60% FiO₂
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G. **1850**: Hemodynamic Consequences
Critical Care Fundamentals: Mechanical Ventilation

a. Cardiac output is determined by a pressure gradient, or high-pressure system leaving the left ventricle and returning to the heart via a low-pressure system via the right atrium

b. **1911** Spontaneous breathing is a negative pressure, which causes a lower pressure system in the thorax and less resistance of blood flow to return to the right atrium and assist in allowing adequate venous return and pre-load

c. **1932** Positive pressure ventilation leads to positive intrathoracic pressure leads to higher right atrial pressures and impede venous return
   i. **1944** The decrease in venous return is amplified when a patient has decreased intravascular volume. This can lead to a decrease in cardiac output and mean arterial pressure = need a fluid bolus to restore intravascular volume and improve preload.

d. **2010**: Right Atrium: Positive pressure is delivered-> increased positive intrathoracic pressure and this pressure is transmitted to the low pressure right atrium -> increase in pressure in the right atrium -> impedance of venous return and decreased preload
   i. This is less of a problem in patients that are not intravascularly volume depleted

e. **2048**: Right Ventricle- Increased intrathoracic pressure leads to increase right ventricular afterload, which is normally well tolerated, except in patients with RV failure (e.g. long standing pulmonary hypertension or acutely from a massive PE)= RV collapse and failure with possible cardiac arrest

f. **2128**: Left Ventricle- Positive intrathoracic pressure leads to a decreased pressure gradient between the ventricle and the intrathoracic space will decrease LV afterload => increased stroke volume and cardiac output
   i. **2150**: Heart failure- beneficial by assisting the LV and allowing more cardiac output
Critical Care Fundamentals: Mechanical Ventilation

Mechanical Ventilation Basics: Part 2

A. 0130 Modes

B. 0212 Terminology
   a. 0216 Breath Type: 3 types of breaths that can be delivered (1) controlled (2) assisted (3) spontaneous
   b. 0228 Breath Delivery: How much volume of gas is delivered to the patient (volume or pressure)
   c. 0235 Mode: How breath types are combined together; examples: CMV, ACV, IMV, PS

C. 0256 Mechanical Ventilator Breaths and Pull-ups: Imagine you have never heard or attempted a pull up for this analogy
   a. 0318 Controlled Breath
      i. No work (You just hang on the bar while the trainer pushes you up the bar a few times)
      ii. Ventilator does all the work; the frequency/ rate of the breaths and the amount of gas delivered is fully dependent on the ventilator
         1. 0551 Example: CMV (controlled mandatory ventilation) - ventilator determines the rate and the amount of gas
   b. 0401 Assisted Breath
      i. Start Work (You make the effort to start doing the pull-up, but the trainer knows you are not strong enough- they then do everything, once they see your effort)
      ii. Ventilator takes over the work: The patient will trigger a breath, and once that is sensed by the ventilator, the ventilator does all the work. The patient can determine the respiratory rate.
         1. 0600 Example: ACV (Assist control ventilaton) - combination of a controlled breath and assisted breath
   c. 0450 Supported Breath (also called spontaneous breath)
      i. Able to do some or most of the work (You are now much stronger to start the pull up. The trainer will only give you some support to complete the pullup. The weaker you are, the more support the trainer has to give you, and the inverse is true- the stronger you are, the less support the trainer has to give you)
      ii. Ventilator assists to finish work (i.e. pressure support). The patient starts the process of taking a breath, and only gets some support from the ventilator. However, most of the work is done by the patient.
         1. 0535 Example: pressure support will assist or augment their efforts
         2. 0608 Example: SIMV (synchronized intermittent mandatory ventilation) - Ventilator combines a controlled or assisted breath with a spontaneous breath

D. 0628 Breath Delivery
   a. 0632 Volume breath: a preset amount of gas is delivered to the patient
      i. 0650: The amount of pressure the ventilator needed to deliver this volume of gas is unknown as this depends on the patient’s compliance
      ii. 0710 The lower the compliance, or the stiffer the lung, the more pressure it will take to deliver the volume
      iii. 0721 As the compliance increases, or the lung gets more stretchy, the less pressure it will take to deliver the same volume of gas
   b. 0657 Compliance= change in volume / change in pressure
      i. 0820 If you are on a volume mode, pay close attention to the pressure;
         1. if the pressure is increasing -> compliance is decreasing
         2. if the pressure is decreasing-> compliance is increasing
      ii. 0850 If you are on a pressure mode, pay close attention to the volume
         1. if the volume is increasing -> compliance is increasing
         2. if the volume is decreasing-> compliance is decreasing
   c. 0730 Pressure breath: a preset pressure will deliver the gas
      i. 0747 The amount of volume that will be delivered to the patient is unknown
ii. **0748** The lower the compliance means that less volume will be delivered to a patient at a given pressure

iii. **0802** To give a larger volume of gas, in a patient with low compliance, a higher preset pressure would need to be given

iv. **0810** As the compliance increases, or the lung gets more stretchy, the more volume will be delivered with the same amount of pressure

E. **0925** Peak inspiratory pressure (PIP)
   a. **1014** Normally should be in the teens, <20 cm of water pressure
      i. **1045** Dynamic Pressure needed to fully inflate the lung and overcome the resistive and elastic forces of the lungs
   b. **1026** Plateau Pressure (PPlat): pressure that alveoli see (inspiratory pause)- static pressure
   c. **1055** PIP > 30 cm of water pressure, need to check the plateau pressure
      i. **1106** Elevated PIP and elevated PPlat= indicate decrease compliance
         1. **1113** Lung itself = pulmonary edema, pneumonia, ARDS, or pulmonary contusion
         2. **1121** Chest wall/ thorax= pneumothorax, pleural effusion, large circumferential burns w. eschar formations
         3. **1136** Abdomen= massive ascites or abdominal compartment syndrome
   d. **1145** Elevated PIP and low PPlat= high resistance in the circuit or patient
      i. Examples: pt biting ET tube, kinked ET tube, increased secretions, mucous plugging, COPD or Asthma

F. **1236** Pressure Vs Volume
   a. **1257**: Advantage of Volume delivered breath
      i. More control over the minute ventilation = tidal volume X respiratory rate
      ii. More clinicians are familiar with volume breaths
   b. **1343**: Disadvantage of Volume delivered breath
      i. As compliance decreases, there will be need for higher peak. Inspiratory pressures, which can lead to barotrauma
      ii. Flow pattern is delivered, constant flow wave form, can lead to patient discomfort and there by increased peak inspiratory pressures = **1433** square breath on the ventilation
   c. **1407** Note: we breath by a decelerating inspiratory wave form
   d. **1456**: Advantage of Pressure delivered breath
      i. Uses a decelerating waveform, which is physiological and can be more comfortable for the patient
      ii. Lower. Peak inspiratory pressure compared to a volume breath
      iii. Improves oxygenation due to a higher mean airway pressure compared to volume breath
   e. **1533**: Disadvantages of Pressure delivered breath
      i. No direct control over minute ventilation; have to make sure the patient is getting an adequate tidal volume for the pressure
      ii. Less familiar to clinicians
      iii. Have to constantly pay attention to the pressures, since compliance is changing a lot, to get an adequate or appropriate tidal volume
Learning objectives

LIST THE GOALS OF MECHANICAL VENTILATION

NAME THE FACTORS THAT CONTROL OXYGENATION AND VENTILATION

DISCUSS COMPLICATIONS THAT MAY ARISE DURING MECHANICAL VENTILATION
Goals of Mechanical Ventilation

1. Maximize patient comfort (MV settings, sedation)
2. Decrease work of breathing/ allow spontaneous breathing
   - One of the main reasons for mechanical ventilation is when your patient is having excessive work of breathing and they were either in respiratory failure or on the verge of respiratory failure.
   - Optimal type of breath is spontaneous breath
3. Provide adequate (not perfect) gas exchange (oxygenation and ventilation)
   - Clearly define oxygen saturation goals
   - Clearly define CO₂ goals
     - Example: A patient with a traumatic brain injury would need a normal CO₂ goal because a high CO₂ would increase cerebral blood flow and thereby increase intracranial pressure.
4. Minimize toxicity
   - Barotrauma- overdistension
   - Volutrauma- high volumes
   - Atelectotrauma- opening and closing alveoli
   - O₂ toxicity- >60% (even for short periods of time)
   - Adverse effects on the cardiovascular system
5. This is a supportive therapy to allow time for other interventions to treat the cause of respiratory failure
Functional Residual Capacity (FRC): Volume of gas in the lungs at end expiration, but prior to inhalation; a state of no gas exchange

Natural tendency is for the lungs to want to collapse due to the natural elastic forces of the lung

Natural tendency of the chest wall to want to expand outwards

- Active process by diaphragmatic contraction into the abdomen and the rib cage to move outwards
- ↑ intra-thoracic volume
- ↓ intra-thoracic pressure
- ↑ Pressure gradient between atmosphere and intra-thoracic space
Exhalation

- Passive process = Diaphragm relax
- Lung recoils
- ↑ intra-thoracic pressure
- Creates a pressure gradient (alveolar pressure exceeds atmospheric pressure) and gas flow proceeds out of the lungs

Active process: obstructive physiology (example: COPD and asthma) causes it to become active
Positive Pressure Ventilation

- Spontaneous breathing occurs via a negative pressure circuit (pulled into the lungs)
- Mechanical ventilation is a complete reversal of normal physiological breathing and occurs via a positive pressure system (pushed into the lungs)
- Air flow into lungs is now the result of a machine (ventilator) pushing or forcing air into the lungs
Oxygenation

Diffusion: oxygen moves down the concentration gradient, down the alveoli and into the capillaries

1. FiO₂ – first way to improve oxygenation
2. PEEP (positive end- expiratory pressure)- second way to improve oxygenation (optimal PEEP)
   a. Mean Airway pressure: average pressure your lung is being exposed to during mechanical ventilation- both inspiration and expiration
   b. I:E ratio (inspiration to expiration) – lungs stay in expiration twice as long as inspiration
3. Inspiratory time: can increase oxygenation, but is usually used for refractory hypoxemia
   a. Increases the mean airway pressure -> improved oxygenation
   b. Allows air re-distribution from highly compliant alveoli to less compliant alveoli
   c. Maintaining a larger surface area at end inspiration and allowing more time for air to diffuse across the alveoli and into the capillaries
Ventilation = removal of CO₂ from the body

Simple diffusion + Convection- CO₂ builds up in the capillaries

Minute Ventilation = Respiratory Rate x Tidal Volume

1. Respiratory Rate
2. Tidal Volume
   × Dead space ventilation- in theory people should breathe in gas that is void of CO₂; however, the CO₂ that remains in the airway mixes w/ the inhaled gas => increased dead space ventilation with worsening respiratory distress/ decreased ventilation => decreased gradient for CO₂ to diffuse out of the capillaries
   × Inhalation of CO₂ “void” gas allows CO₂ to diffuse out of the capillaries and into the alveoli, which is removed with exhalation; if we breathe in a larger tidal volume, this will extend the alveoli, which increases the transfer of CO₂ or breath faster by increasing the respiratory rate
   × Tidal volume- limit to how much can deliver, goal 4-8 ml/kg of predicted body weight
      • If give too much-> volutrauma
3. Expiratory Time
   × Obstructive Lung Disease (e.g. COPD and Asthma)- want to decrease the respiratory rate to allow more time in exhalation because if the expiratory time is too short then the CO₂ is trapped
Complications of Mechanical Ventilation

**Ventilator Associated Lung Injury (VILI)**

1. Barotrauma: injury to alveoli, caused by excessive pressure from the ventilator
   - Plateau pressure, aka the pressure that the alveoli see- > this is seen by doing an inspiratory pause
   - Limit the plateau pressure to < 30 mmHg
2. Volutrauma: over distension of alveoli from excessive tidal volume (Vt)
   - Limit the tidal volumes to 4-8 ml/ kg of predicted body weight
3. Atelectrotrauma: damage which may occur when repetitively opening and closing lung units (a type of sheering stress to the lung)
   - Importance of Optimal PEEP
   - End Inspiration: well expanded and optimal to provide adequate gas exchange
   - Expiration with inadequate PEEP: the alveoli collapse and develop atelectasis; a lot more pressure will be needed to expand the alveoli from the collapsed state to the volume at end expiratory-> sheer stress
   - Expiration with adequate PEEP: less pressure is needed to re-expand the alveoli at end expiration-> have not allowed the alveoli to close and become atelectatic
Driving Pressure - difference between the plateau pressure and the PEEP

4. Biotrauma: lung injury resulting from inflammation mediators (precipitated by VILI) this can be caused by barotrauma, volutrauma, or atelectotrauma

5. Oxygen Toxicity: lung injury due to O₂ induced production of free radicals
   - Using a goal of <100% saturation allows weaning of FiO₂ and decrease risk of oxygen toxicity; goal of <60% FiO₂
Hemodynamic Consequences

Cardiac output is determined by a pressure gradient, or high-pressure system leaving the left ventricle and returning to the heart via a low-pressure system via the right atrium.

Spontaneous breathing is a negative pressure, which causes a lower pressure system in the thorax and less resistance of blood flow to return to the right atrium and assists in allowing adequate venous return and pre-load.
Positive pressure ventilation leads to positive intrathoracic pressure leads to higher right atrial pressures and impede venous return.

The decrease in venous return is amplified when a patient has decreased intravascular volume. This can lead to decrease in cardiac output and mean arterial pressure = need a fluid bolus to restore intravascular volume and improve preload.
Critical Care Fundamentals: Mechanical Ventilation

- **Right Atrium**
  - Positive pressure is delivered -> increased positive intrathoracic pressure and this pressure is transmitted to the low pressure right atrium -> increase in pressure in the right atrium -> impedance of venous return and decrease preload
  - This is less of a problem in patients that are not intravascularly volume depleted

- **Right Ventricle**
  - Increased intrathoracic pressure leads to increase right ventricular afterload, which is normally well tolerated, except in patients with RV failure (e.g. long standing pulmonary hypertension or acutely from a massive PE) => RV collapse and failure with possible cardiac arrest

- **Left Ventricle**
  - Positive intrathoracic pressure leads to a decreased pressure gradient between the ventricle and the intrathoracic space will decrease LV afterload => increased stroke volume and cardiac output

- **Heart failure**
  - beneficial by assisting the LV and allowing more cardiac output
**CENTRAL ILLUSTRATION:** Potential Physiological Effects of Positive End-Expiratory Pressure on Ventricular Function and Cardiac Output

- Right ventricular (RV) venous return
- Pulmonary vascular resistance due to vascular compression
- RV dilation $\rightarrow$ left shift in septum
- Compensatory increase in systemic vascular resistance

- Hypoxia mediated pulmonary vasoconstriction

- Left ventricular (LV) afterload
- LV preload and LV dilatation
- Myocardial oxygen demand
- Pressure gradient from thorax to periphery
- Hydrostatic displacement of alveolar edema

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Clinical Pearls

- Net effect of positive end-expiratory pressure (PEEP) on cardiac output (CO) depends on RV/LV function, preload, afterload, and ventricular interdependence.
- In RV failure/preload dependence, moderate to high PEEP (5-15 cmH$_2$O) may decrease RV CO.
- In afterload dependent states (e.g., LV failure), moderate to high PEEP (10-15 cmH$_2$O) may improve CO.

Learning objectives

NAME THE 3 TYPES OF BREATHS

LIST THE 2 WAYS BREATHS CAN BE DELIVERED
Modes 0130

**Terminology**

**Breath Type**: 3 types of breaths that can be delivered

1. controlled
2. assisted
3. spontaneous

**Breath Delivery**: How much volume of gas is delivered to the patient

- Volume
- Pressure

**Mode**: How breath types are combined together; examples: CMV, ACV, IMV, PS
Imagine you have never heard or attempted a pull up for this analogy

1. Controlled Breath
   - No work (You just hang on the bar while the trainer pushes you up the bar a few times)
   - Ventilator does all the work; the frequency/rate of the breaths and the amount of gas delivered is fully dependent on the ventilator
     - Example: CMV (controlled mandatory ventilation)- ventilator determines the rate and the amount of gas

2. Assisted Breath
   - Start Work (You make the effort to start doing the pull-up, but the trainer knows you are not strong enough. Then they then do everything, once they see your effort.
   - Ventilator takes over the work: The patient will trigger a breath, and once that is sensed by the ventilator- the ventilator does all the work. The patient can determine the respiratory rate.
     - Example: ACV (Assist control ventilation)- combination of a controlled breath and assisted breath

3. Supported Breath (also called spontaneous breath)
   - Able to do some or most of the work (You are now much stronger start the pull up. The trainer will only give you some support to complete the pullup. The weaker you are, the more support the trainer has to give you, and the inverse is true- the stronger you are, the less support the trainer has to give you.)
   - Ventilator assists to finish work (i.e. pressure support). The patient starts the process of taking a breath, and only gets some support from the ventilator. However, most of the work is done by the patient.
     - Example: pressure support will assist or augment their efforts
     - Example: SIMV (synchronized intermittent mandatory ventilation)- Ventilator combines a controlled or assisted breath and combine with a spontaneous breath

**Breath Delivery**

**Volume breath**: a preset amount of gas is delivered to the patient
× The amount of pressure the ventilator needed to deliver this volume of gas is unknown, as this depends on the patient’s compliance
× The lower the compliance, or the stiffer the lung, the more pressure it will take to deliver the volume
× As the compliance increases, or the lung gets more stretchy, the less pressure it will take to deliver the same volume of gas

**Pressure breath:** a preset pressure will deliver the gas

× The amount of volume that will be delivered to the patient is unknown, as this depends on the patient’s compliance
× The lower the compliance means that less volume will be delivered to a patient at a given pressure
× To give a larger volume of gas, in a patient with low compliance, a higher preset pressure would need to be given
× As the compliance increases, or the lung gets more stretchy, the more volume will be delivered with the same amount of pressure

**Compliance** = change in volume / change in pressure

× If you are on a volume mode, pay close attention to the pressure
  o ↑ pressure = ↓ compliance
  o ↓ pressure = ↑ compliance
× If you are on a pressure mode, pay close attention to the volume
  o ↑ volume = ↑ compliance
  o ↓ volume = ↓ compliance
Critical Care Fundamentals: Mechanical Ventilation

Peak inspiratory pressure (PIP):
- Normally should be in the teens, <20 cm of water pressure
- Dynamic Pressure needed to fully inflate the lung and overcome the resistive and elastic forces of the lungs

Plateau Pressure (PPlat):
- Pressure that alveoli see (inspiratory pause)
- Static pressure since there is no air movement
- PIP > 30 cm of water pressure, need to check the plateau pressure

Airway Resistance:
- PIP – Plateau Pressure
- Normally <5cmH20 unless excessive airway resistance
Elevated PIP and elevated PPlat= indicate decrease compliance (↑ PIP + ↑ PPlat = ↓ compliance)

Lung itself= pulmonary edema, pneumonia, ARDS, or pulmonary contusion

Chest wall/ thorax= pneumothorax, pleural effusion, large circumferential burns w. eschar formations

Abdomen= massive ascites or abdominal compartment syndrome

Elevated PIP and low PPlat= high resistance in the circuit or patient

Examples: patient biting ET tube, kinked ET tube, increased secretions, mucous plugging, COPD or Asthma

Pressure Vs Volume 1236

Advantage of Volume delivered breath

× More control over the minute ventilation = tidal volume X respiratory rate
× More clinicians are familiar with volume breaths

Disadvantage of Volume delivered breath
As compliance decreases there will be need for higher peak inspiratory pressures, which can lead to barotrauma. Flow pattern is delivered, constant flow wave form, can lead to patient discomfort and there by increased peak inspiratory pressures = square breath on the ventilation. Note: we breath by a decelerating inspiratory wave form.

Advantage of Pressure delivered breath

- Uses a decelerating waveform, which is physiological and can be more comfortable for the patient.
- Lower. Peak inspiratory pressure compared to a volume breath.
- Improves oxygenation due to a higher mean airway pressure compared to volume breath.

Disadvantages of Pressure delivered breath

- No direct control over minute ventilation; have to make sure the patient is getting an adequate tidal volume for the pressure.
- Less familiar to clinicians.
- Have to constantly pay attention to the pressures, since compliance is changing a lot, to get an adequate or appropriate tidal volume.
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<td>Volume Assist/Control</td>
<td>Assisted or Controlled</td>
<td>Preset Tidal Volume</td>
<td>PIP &amp; Plateau Pressures</td>
<td>Control tidal volume (lung protective) Control of minute ventilation (RR &amp; Vt)</td>
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<td>Pressure Assist/Control</td>
<td>Assisted or Controlled</td>
<td>Preset Pressure</td>
<td>Adequate Tidal Volumes (not too high or low)</td>
<td>Patient comfort (decelerating flow), Control over delivered pressures (avoid barotrauma)</td>
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<td>Pressure Support (PS)</td>
<td>Supported</td>
<td>Preset Pressure</td>
<td>Adequate Tidal Volumes (not too high or low)</td>
<td>Patient comfort Allows patient to maintain respiratory work effort</td>
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<tr>
<td>Synchronized Intermittent Mandatory Ventilation (SIMV) • PS</td>
<td>Assisted, Controlled or Supported</td>
<td>PC-SIMV=Preset Pressure</td>
<td>PC-SIMV=Adequate Tidal Volumes (not too high or low)</td>
<td>Can get benefits of supported breaths (PS), but still ensure minimum number of mandatory breaths (controlled or assisted)</td>
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<td>Pressure Regulated Volume Control (PRVC)</td>
<td>Assisted or Controlled</td>
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