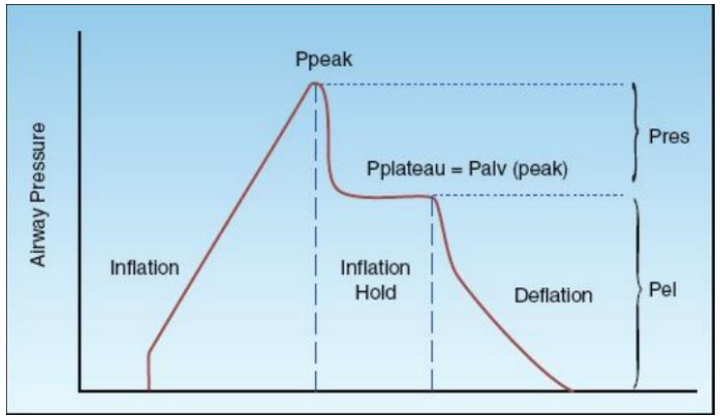
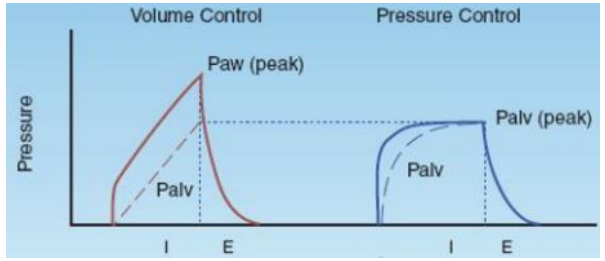
Basics of Mechanical Ventilation



Airway pressure profile for a constant-flow, volume-controlled lung inflation with a brief end-inspiratory occlusion (inflation-hold). **Ppeak** is the peak airway pressure, **Pplateau** is the end-inspiratory occlusion pressure, **Palv (peak)** is the peak alveolar pressure at end-inspiration, **Pres** is the pressure attributed to airway resistance, and **Pel** is the pressure attributed to the elastic recoil force of the lungs and chest wall



Pressure and changes during a single ventilator breath using volume control and pressure control methods of lung inflation at equivalent tidal volumes. Changes in airway pressure (Paw) are indicated by the solid lines, and changes in alveolar pressure (Palv) are indicated by the dashed lines. I = inspiration, E = expiration.

Volume control

- Due to airflow at the end of inspiration, the peak pressure in the airways (Paw) is greater than the peak pressure in the alveoli (Palv)
- The difference (Paw – Palv) is the pressure dissipated by the resistance to flow in the airways.
- The peak alveolar pressure is a reflection of the alveolar volume at the end of lung inflation

Advantages:

- Constant tidal volume despite changes in lung compliance and airway resistance

Disadvantages

- Airway pressures including alveolar pressures may be higher with decreased compliance of lungs due to constant TV

• Volume-targeted: vent delivers a set tidal volume, pressure depends on airway resistance and compliance. Patient remains at risk for barotraumas / volutrauma from high pressures.

Pressure control

- The desired inflation pressure is preselected, and a decelerating inspiratory flow rate provides high flows at the onset of the lung inflation, to attain the desired inflation pressure quickly
- Since there is no airflow at the end of inspiration, the end-inspiratory airway pressure is equivalent to the peak alveolar pressure

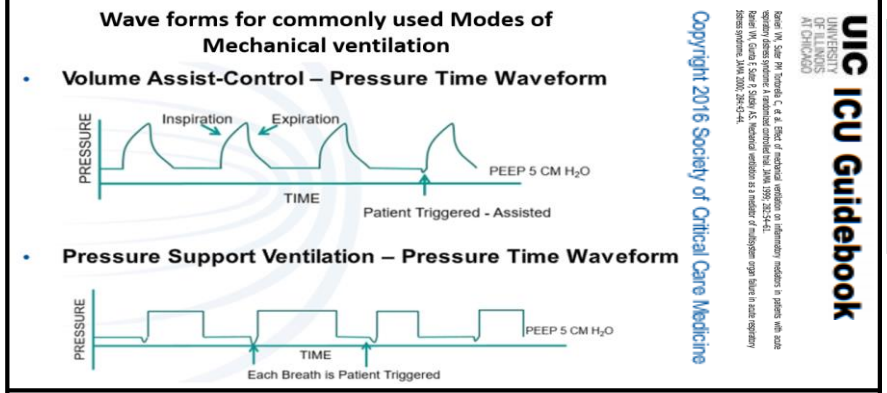
Advantages:

- Major benefit of PCV is the ability to control the peak alveolar pressure, which is the pressure most closely related to the risk of alveolar overdistension and ventilator-induced lung injury

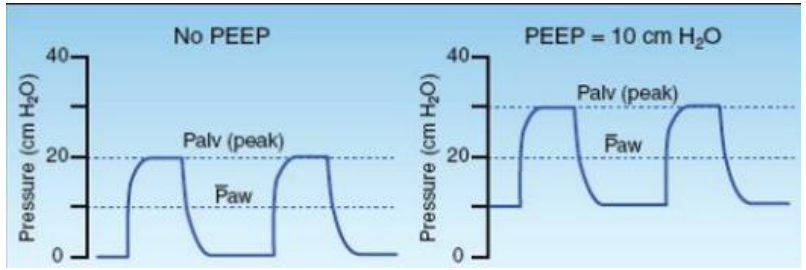
Disadvantages

- Decrease in alveolar volume (and hence ventilation) that occurs when there is an increase in airway resistance or a decrease in lung compliance.

• Pressure-targeted: vent delivers volume until a set pressure is achieved. Now, tidal volume is dependent on airway resistance and compliance. Patient remains at risk for low tidal volumes and inadequate minute ventilation.



Positive End Expiratory Pressure



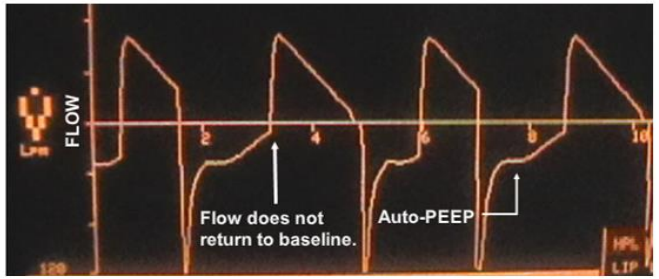
The change in peak alveolar pressure determines the influence of PEEP on alveolar ventilation (hence arterial oxygenation)

The change in mean airway pressure determines the influence of PEEP on cardiac output

Progressive narrowing of the airways during expiration results in collapse of distal airspaces (small airways and alveoli) at the end of expiration.

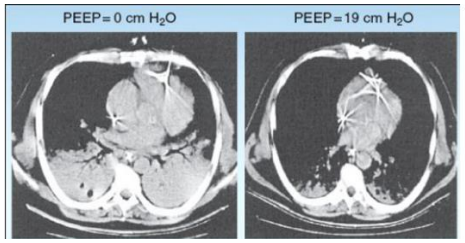
This has two adverse consequences: (a) impaired gas exchange from atelectasis (b) atelectrauma from repetitive closing and opening of the distal airspaces

PEEP is applied to prevent this collapse and reopen distal airspaces that are persistently collapsed

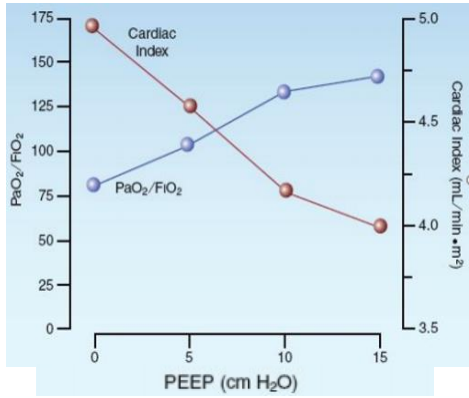


Auto-PEEP can occur when patient has inadequate time to exhale before next breath is delivered

- Consequences
  - ↑Alveolar pressures
  - Hypotension
  - Worsened oxygenation
- Interventions to decrease auto-PEEP
  - ↓Respiratory rate
  - ↓Tidal volume
  - ↑Flow rate



CT images from a patient with ARDS showing the influence of PEEP on lung aeration (alveolar recruitment)



The opposing effects of positive end-expiratory pressure (PEEP) on arterial oxygenation (PaO2 /FIO2) and cardiac index in patients with ARDS

Troubleshooting

• **Low pO2** = **oxygenation issue** = increase FiO2, increase PEEP (to recruit more alveoli).

• **High pCO2** = **ventilation issue** = Increase Minute Ventilation by increasing TV or rate (suction, bronchodilators)

High Peak pressures & High Plateau Pressures (non-compliant lungs)

• Pulmonary edema • Worsening consolidation • ARDS • Atelectasis • Mainstem intubation • Tension PTX • Decreased chest wall compliance

High peak pressure low & normal plateau pressure (airway problem)

• Bronchospasm • Mucous plug • Secretions • Obstructed tubing • Patient biting tube

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