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Learning Objectives

Upon completion of this program, participants will be able to:

- Review the basic principles of mechanical ventilation
- Apply mechanical ventilation principles to improve the delivery of pharmaceutical care

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Disclosures

- I have no real or apparent conflicts of interest to disclose
- I will not be discussing off-label or investigational uses of medications

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Mechanical Ventilation: What The Pharmacist Should Know

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Background

- Mechanical ventilation goes back to 1555
  - First negative pressure ventilation device was developed in 1920
  - First **positive pressure** ventilation device was developed in 1950 during the polio pandemic
- Mechanical ventilation is a basic and life-saving intervention among critically ill patients to support a patient's airway and prevent tissue hypoxia

Marino PL, Sutin KM. The ICU Book. 3rd edition. Philadelphia, PA. Lippincott Williams & Wilkins
Cawley MJ. Journal of Pharmacy Practice. 2011;24(1):7-16
Barbarash RA, Dasta JF, ed. DICP. 1990;24(10):959-970.

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Background

vs.

Cawley MJ. Journal of Pharmacy Practice. 2011;24(1):7-16
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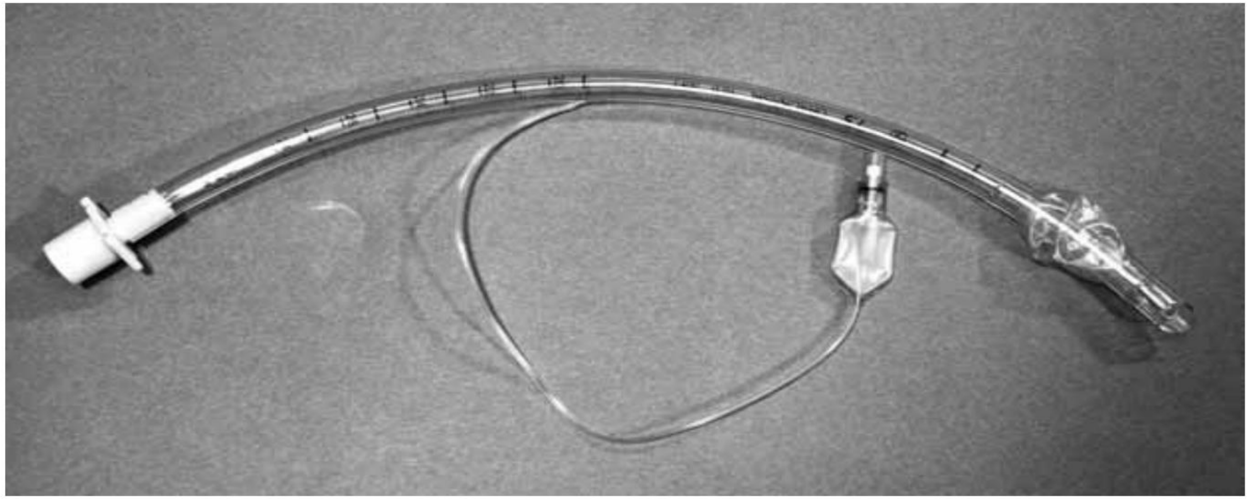
Indications

- To maintain oxygenation and ventilation:
  - Acute respiratory distress syndrome
  - Acute exacerbation of COPD/asthma
  - Airway collapse due to neuromuscular disease
- Airway protection:
  - Coma
- Combination of both

Mehta, M. ICU Rounds. In: The Hospitalist Manual. Shelton, CT: People's Medical Publishing House; 2010: 124-129
Cawley MJ. Journal of Pharmacy Practice. 2011;24(1):7-16

Basic Principles

- Positive pressure mechanical ventilation is achieved by placing Endotracheal Tube (ETT)
  - **Mouth** or nose



- ETT is smaller than our own airway
  - Results with more resistance and increase work of breathing

Patient-ventilator dyssynchrony

Marino PL, Sutin KM. The ICU Book. 3rd edition. Philadelphia, PA. Lippincott Williams & Wilkins

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Basic Principles

- Tidal volume (TV):
  - Volume of gas inhaled or exhaled
- Minute ventilation (MV):
  - Total volume of gas entering or leaving the lung per minute
  - Product of tidal volume and respiratory rate
  - Tidal volume X respiratory rate
- Fraction of inspired oxygen (FiO_2)
  - Percentage of oxygen
- Positive end expiratory pressure (PEEP)
  - The remaining pressure during the exhalation phase

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Basic Principles: Monitoring

- ABG:
  - PH
  - PCO_2
  - PaO^2
  - HCO_3
- Pulse Ox:
  - SpO_2

Ventilation (RR/TV)

Oxygenation (FiO_2/PEEP)

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Basic Principles: Modes

- Assist-control ventilation (AC/VC):
  - Preset tidal volume and pressure varies

- Pressure controlled (PCV):
  - Preset pressure and the volume varies

- Both modes have:
  - Trigger
  - Cycle
  - Limit

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Basic Principles: Modes

- Assist-control ventilation (AC/VC):
  - Provides specific tidal volume and respiratory rate but the patient can generate additional tidal volume breaths
  - If the ventilator is stopping any patient's own breath, then it is called control-mode ventilation (CMV)
  - Simplicity and control the TV
  - For spontaneously breathing patients with weakened respiratory muscles
  - Hyperventilation and respiratory alkalosis (more of problem with stacking)

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Basic Principles: Modes

- Pressure controlled (PCV):
  - Provides a constant pressure throughout the inspiratory phase over constant time
  - Volume varies
  - Initial severe ARDS management might require PCV
  - Patients who failed AC/VC or have increased peak airway pressures during AC/VC or apneic patients
  - MORE, MORE and MORE sedation, paralysis, and pneumothorax

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Basic Principles: Modes

- Pressure Support (PSV):
  - All breaths are patient initiated
  - Patient controls the rate, tidal volume, and minute ventilation
  - Preset pressure that is delivered with each spontaneous patient breath
  - Most comfortable
  - Weaning mode, to decrease the airway resistance and dead space

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Mechanical Ventilation Complications

- Circulation:
  - Thorax
  - Abdomen
  - Periphery

Pharmacologic cardiovascular support

- Mechanical ventilation results with changes in lung pressure and volume which might result with:
  - Atrial filling (preload) reduction
  - Resistance to ventricular emptying (afterload)
  - Right atrial pressure increases during mechanical ventilation which can lead to decreases in RV preload and a fall in cardiac output

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Mechanical Ventilation Complications

- Pneumothorax
- Oxygen toxicity
- Ventilator associated pneumonia
- Neuromuscular and muscular weakness
- Sedation and delirium

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Mechanical Ventilation and ARDS

- Ventilator-induced lung injury (VILI):
    - Lung stress (pressure)
    - Lung strain (volume)
    - Plateau pressure?

- Benefit of using lung protection ventilation:
    - Minimize overdistension
    - Minimize hemodynamic compromise

Papazian L, et al. Ann Intensive Care 2019;9(1):69
Young M, et al. Critical Care Nursing Quarterly. 2019;42(4):392-399

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Mechanical Ventilation and ARDS

- ARMA by ARDS Network:
    - Lower tidal volumes starting at 6 ml/kg, reduced by 1 ml/kg to maintain plateau pressure ≤30 cmH2O
    - Traditional tidal volumes starting at 12 ml/kg, reduced by 1 ml/kg PBW to maintain plateau pressure ≤50 cmH2O
    - Volume assist-control for both

    - Low tidal volume ventilation resulted with lower mortality and more ventilator-free days

Brower RG, et al. *N Engl J Med* 2000;342(18):1301–8

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Mechanical Ventilation and ARDS

- Where to start from:
  - Tidal volume = 6 mL/kg
  - High respiratory rate of 25-30 breaths/ min
  - Partial pressure of carbon dioxide (PaCO2) <50 mmHg
  - Plateau pressure <30 cm H2O
  - PEEP of >5 cm H_2O in all ARDS patients
  - High PEEP reserved for moderate to severe ARDS to increase oxygenation without decrease respiratory compliance or hemodynamic status

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Sedation

- Respiratory center inhibition
  - Reduction of lung injury
- Improve patient-ventilator synchrony
- Reduction of oxygen consumption
- Agents:
  - Opioids
  - Propofol
  - Benzodiazepines

Brower RG, et al. N Engl J Med 2000;342(18):1301–8
Jacobi J, et al. Crit Care Med.2002;30:119-141

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Sedation

- Over sedation:
    - Prolonged mechanical ventilation
    - Increase length of stay
    - Increased risk of complications
    - Increased diagnostic testing = $$$
    - Delirium

Brower RG, et al. N Engl J Med 2000;342(18):1301–8
Jacobi J, et al. Crit Care Med.2002;30:119-141

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Conclusion

- Mechanical ventilation is lifesaving and life-sustaining modality among critically ill patients
- Pharmacists must always evaluate sedation plans for mechanical ventilated patients
- Over sedation could delay the recovery of mechanical ventilated patients