JOHNS HOPKINS
MEDICINE

Module 4:
Understanding Mechanical Ventilation

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Objectives

Upon completion of this module, the learner will be able to:

- Identify types of airways and indications and precautions of each
- Identify common modes of ventilation and be able to describe the assistance each mode provides
- Interpret common alarms associated with mechanical ventilation and indicate an action for each
- Describe possible complications associated with mechanical ventilation
- Discuss and synthesize common weaning parameters and methods

Why is mechanical ventilation required?

- Impending or existing respiratory failure
  - Failure to oxygenate (inadequate exchange of gases at the alveolar level, as seen in acute respiratory distress syndrome [ARDS])
  - Failure to ventilate (decreased mental status or decreased lung compliance)
  - Combination of both
- Airway protection

Cheung AM et al. *Am J Respir Crit Care Med.* Sep 1 2006;174(5):538-544. Fletcher SN et al. *Crit Care Med.* Apr 2003;31(4):1012-1016.
Herridge MS et al. *N Engl J Med.* Feb 20 2003;348(8):683-693.

Other things to consider…

- What type of airway is in place?
- What are the ventilator settings and what do they all mean?
- What do I do if the vent alarms?
- What to I do if the vent fails?
- How do I plan treatment in conjunction with vent weaning?

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Start with the ABC's…

Airway

Airway Management

- Endotracheal Tube (ETT)
- Can be placed orally (most common) or nasally
- Passes through the vocal cords

Airway Management

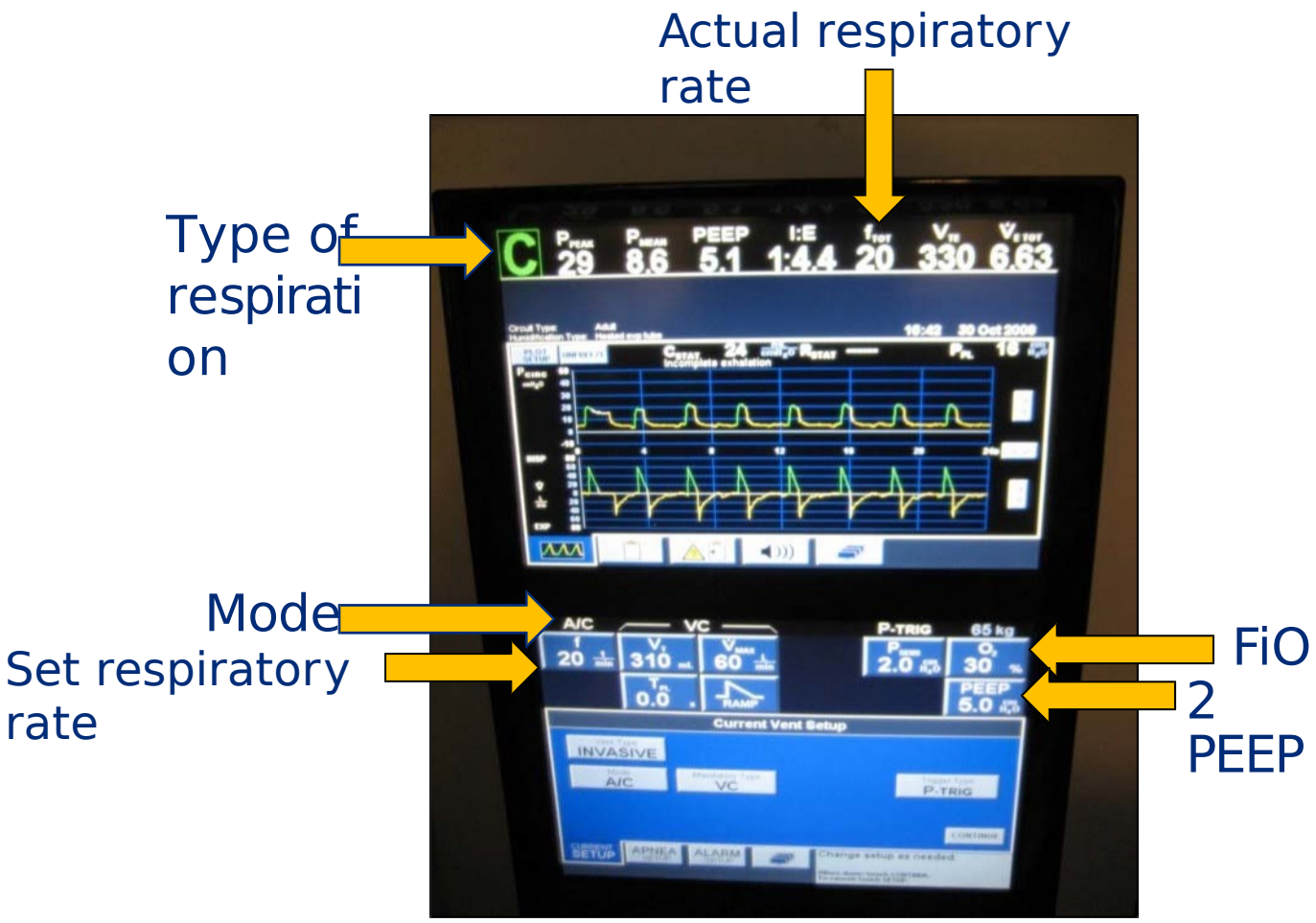
- Tracheostomy tube
- Cuff or cuff less
- Inserted below the vocal cords
- Used in more long-term airway management

Airway Management

- Airway cuffs:
  - Assist with holding the airway in place
  - Allow positive pressure ventilation without loss of tidal volume
  - May reduce risk of aspiration of oral and gastric secretions
  - If patient can talk or is losing tidal volume, the cuff may not be fully inflated

Ventilator Settings

- Tidal Volume
- PEEP
- Mode (type of assist given by vent)
- Rate (Breaths per minute.Adjusted based on patient's own respiratory rate)
- FiO2 (amount of O2 being delivered)


Actual respiratory rate
Type of respiration
Mode
Set respiratory rate
FiO
2
PEEP
C
29
8.6
PEEP
5.1
I:E
1:4.4
20
330
6.63
A/C
VC
P-TRIG
65 kg
20
310
60
0.0
2.0
30
PEEP
5.0
Current Vent Setup
INVASIVE
A/C
VC
P-TRIG
SETUP
APNEA
ALARM

PEEP

Positive End-Expiratory Pressure

- Pressure given in expiratory phase to prevent closure of the alveoli and allow increased time for O2 exchange
- Used in pts who haven't responded to treatment and are requiring high amount of FiO2
- PEEP will lower O2 requirements by recruiting more surface area
- Normal PEEP is approximately 5cmH20. Can be as high as 20cmH20

Oxygen Therapy

- Prolonged exposure to high levels of oxygen can be toxic to the lungs
- High FiO2 (>.5) can lead to atelactasis
- Balancing act between FiO2 and PEEP

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Modes of Ventilation

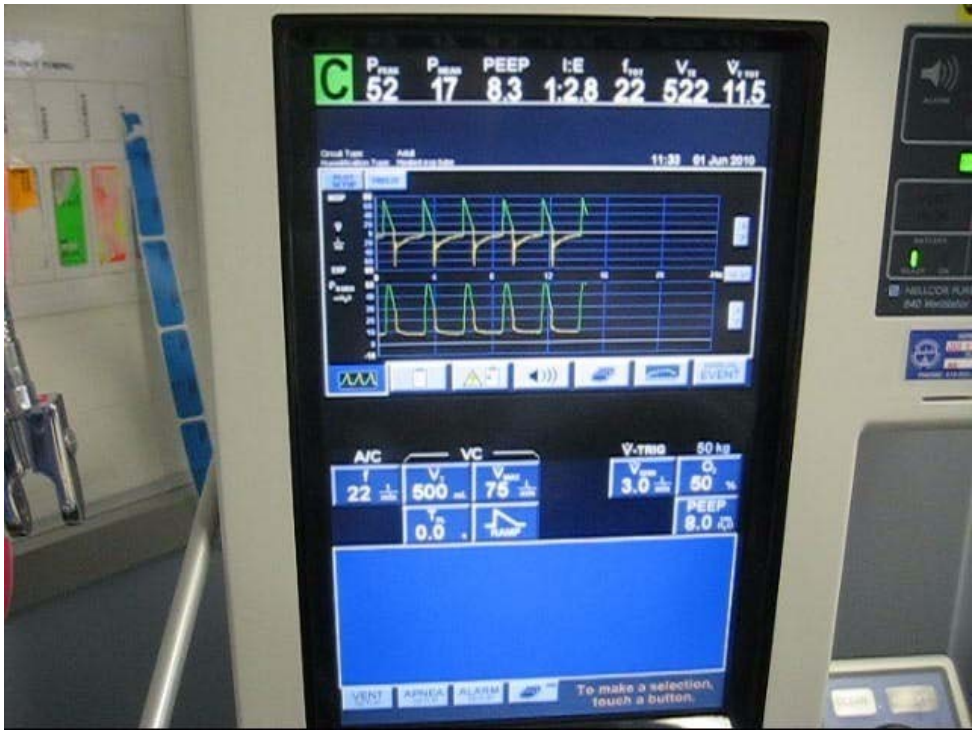
Modes of Ventilation

- Controlled Ventilation
  - Vent initiates all breaths at a pre-set rate and tidal volume
  - Vent will block any spontaneous breaths
  - Used mainly in the OR for paralyzed and sedated patients.

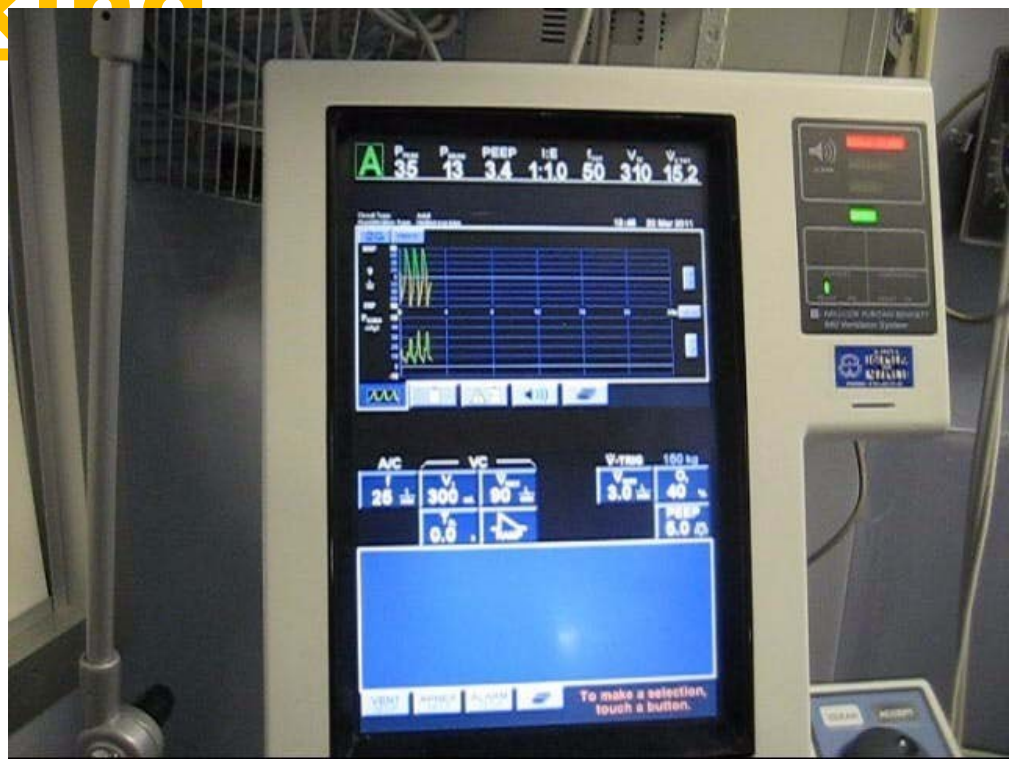
Modes of Ventilation

- Assist Control (A/C)
  - Vent will allow a patient to initiate a breath and then vent will deliver a pre-set tidal volume
  - Machine set at a minimum rate so apnea will not occur if the patient does not initiate a breath
  - Disadvantages:
    - Hyperventilation if patient has increased respiratory rate (can lead to respiratory alkalosis)
    - Vent dysynchrony, breath-stacking

Assist Control (A/C)



“Breath-Stacking”



Modes of Ventilation

- Synchronized Intermittent Ventilation (SIMV)
  - Similar to A/C, but patients can take own breaths with their own TV between mechanically assisted breaths
  - Can be used as a primary mode or a weaning mode
  - May lead to a low respiratory rate in a patient who does not initiate breaths if set rate is low

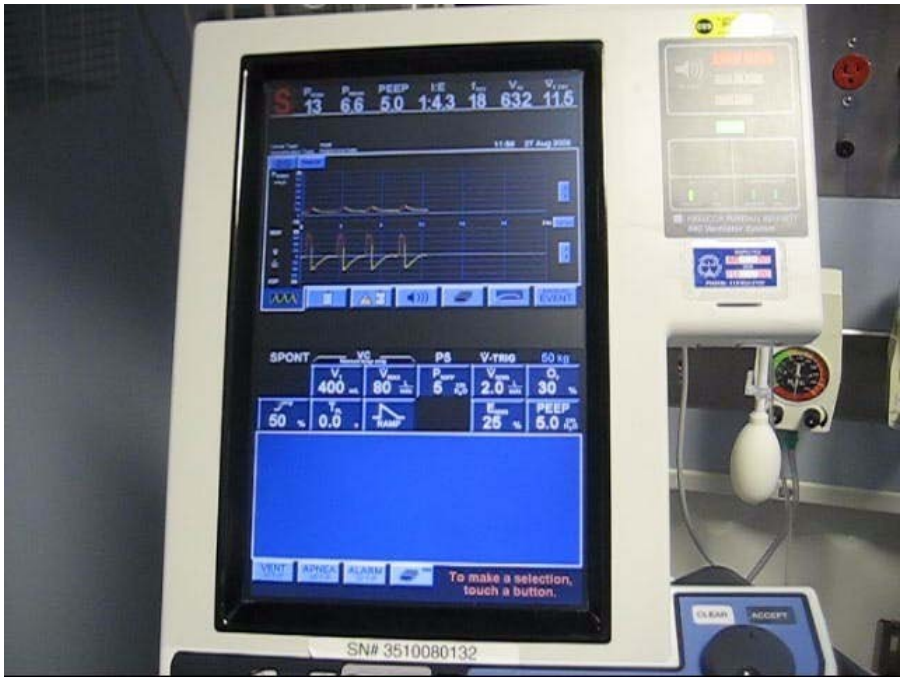
SIMV

A
34 8.3 5.8 1:2.4 19 162 5.04
SIMV
VC
PS
V-TRIG
95 kg
12
360
70
10
1.0
30
75
0.0
25
PEEP
5.0
To make a selection, touch a button.

Modes of Ventilation

- Pressure Support Ventilation (PSV)
  - Also called “spontaneous mode”
  - Pt initiates breath & vent delivers a pre-set inspiratory pressure to help overcome airway resistance and keeps airways open
  - Patient controls the rate, tidal volume, and minute ventilation
  - Tidal volume is variable
  - Can be used in conjunction with SIMV or CPAP settings

Pressure Support (PS)



Modes of Ventilation

- Continuous Positive Airway Pressure (CPAP)
  - Positive airway pressure provided during both inspiration and expiration
  - Vent provides O2 and alarms, but no respirations
  - Improves gas exchange and oxygenation in patients able to breathe on their own
  - Can also be used non-invasively via a face or nasal mask for patients with sleep apnea

Modes of Ventilation

- Airway Pressure Release Ventilation (APRV)
  - Differs from conventional vent
  - Elevation of airway pressures with brief intermittent releases of airway pressure
  - Facilitates oxygenation and CO_2 clearance
  - May be an improved way to treat ALI/ARDS

Non-Invasive Ventilation (NIV)

- Bi-Level Airway pressure (BiPAP)
  - Delivered by mask, not through an airway
  - Similar to CPAP, but can be set at one pressure for inhalation and another for exhalation.
  - Used in sleep apnea, but also has been found to be useful in patients with CHF and respiratory failure to avoid intubation

Vent Alarms

High Pressure Alarm (common alarm to come and go…more serious if it continues to alarm):

- Secretions/ needs to be suctioned (common)
- Kinked tubing/ malposition of ETT
- Pt biting tube/ fighting vent
- Water in tubing (common)
- Bronchospasm
- Pneumothorax
- Decreased compliance (i.e.ARDS)

Vent Alarms

- Low Pressure Alarm
  - Tubing disconnect from vent
  - Leak in cuff or tubing connections (if patient can talk around trach, a leak in the cuff is probable)
  - Extubation
- Also alarms for tidal volume, rate, temperature, and O_2

Vent Alarms

- General principles…
  - Look at the patient first!!! Then follow tubing to the vent to search for any disconnections.
  - If can't find the problem and the patient is in distress, disconnect the patient from the vent and bag with 100% O2 (and call for help)

Complications of Mech Vent

- Asynchrony ("bucking")
- AutoPEEP
  - Patient doesn't expire full tidal volume and air becomes trapped
  - Can cause increased alveolar damage
- Barotrauma
  - Damage to alveoli caused by increased pressure and volume

Complications of Mech Vent

- Hemodynamic compromise
- Nosocomial infection
- Anxiety/ Stress/ Sleep deprivation
- Ulcers/ Gastritis/ Malnutrition
- Muscle deconditioning/ Vent dependence
- Increased intrathoracic pressure leading to systemic edema due to decreased venous return

Weaning parameters

- Adequate Oxygenation
  - PaO_2 >60-70 on FiO_2 .4 to .5, PEEP 5-8cmH20
  - PaO_2/FiO_2 ratio >150-200
- Adequate Ventilation
  - $PaCO_2$ 35-45mmHg
  - pH 7.3 to 7.45

Weaning parameters

- Adequate Respiratory Mechanics
  - Tidal Volume
  - Respiratory Capacity
  - Minute Ventilation
- Hemodynamic Stability

Spontaneous Breathing Trials (SBT)

- Spontaneous breathing trials (whether single or multiple trials) lead to extubation more quickly than those receiving Pressure Support and IMV for weaning purposes in patients who are mechanically ventilated for > 1 week

Weaning parameters

- Signs of distress during weaning…
  - Increased tachypnea (>30)
  - Increased heart rate
  - Irregular breathing pattern or use of accessory muscles
  - Agitation or panic unrelieved by assurance
  - Decrease pH to less than 7.25-7.3 with increasing PCO2

Treatment Guidelines

- Consider the need for increased FiO2 or vent support prior to mobilizing a patient in order to maximize their pulmonary status
- Communicate with medical team to discuss best settings
- Consider how weaning trials may affect the patient's ability to participate in therapy. May want to coordinate working with patients around weaning schedules, and not during

Mobilizing the Patient requiring Mechanical Ventilation

- Patients weaning from mechanical ventilation
  - Consider each patient's case and determine their ability to tolerate both spontaneous breathing trials (SBTs) and rehab sessions
  - May be optimal to treat prior to SBT or after they are rested
  - Consider mobility and strengthening first, then weaning

Ambulating a Patient on Mech Vent

- Requires teamwork with the entire medical team
- Most standard ventilators do not run on battery. Will likely need to use a portable ventilator or an ambu-bag to ventilate the patient while mobilizing

Ambulating a Patient on Mech Vent

- ETT placement
  - Make sure tape is secure prior to moving patient!!!
  - Look at cm mark at lip before and after treatment to assure no movement had occurred
- May want to talk with team if patient has an FiO2 of .60 or greater and/or if PEEP is -10cm H2O or greater to ensure medical stability

Steps to Mobilization…

- Look at Baseline Vitals…

Steps to Mobilization…

- Look at Baseline Vent Settings…

Steps to Mobilization…

- Locate all, wires, tubes, etc.

Steps to Mobilization…

- Move IV pole and lines to the side you are getting up on (usually towards the vent)

Steps to Mobilization…

- Assist patient to sitting at the side of the bed towards the vent, making sure that all lines are accounted for and have enough slack

Steps to Mobilization…

- Transfer to the chair while managing lines to ensure clearance

Steps to Mobilization…

- Try to consolidate equipment together as best as you can

Steps to Mobilization.

- Coordinate with RT to place on portable vent (if necessary)

Steps to Mobilization…

- Organize as much as you can to have all lines in front of the patient. Make sure no lines are on the floor or can get caught in the equipment.

Steps to Mobilization…

- The RT leads with vent/IV pole.The PT supports lines and vent tubing along with assisting the patient

Steps to Mobilization…

- Have a tech or nurse follow with a wheelchair for safety

Steps to Mobilization…

- Always ensure that you have control of all lines and vent tubing/ETT with all transfers and movement of the patient

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