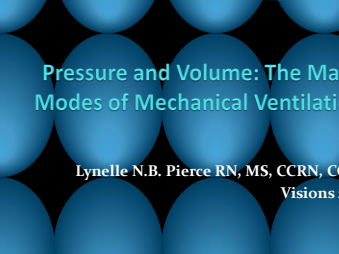


# Pressure and Volume: The Many Modes of Mechanical Ventilation

Lynelle N.B. Pierce RN, MS, CCRN, CCNS  
Visions 2015



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## Objectives

- Delineate a nomenclature for classification of modes of mechanical ventilation.
- Compare the various pressure and volume modes of mechanical ventilation in terms of settings, patient-ventilator interaction, and focus areas of monitoring.
- Analyze patient data to formulate clinical decisions about management of the mechanically ventilated patient.

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**VENTILATOR MODE NOMENCLATURE**

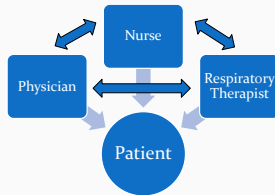
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## Team Sport



## Drager Evita XL



## Maquet Servo-i





## VENTILATOR MODES: Nomenclature

- A breath is *assisted* if the ventilator performs all or some of the work.
- The Control Variable
  - Pressure (P)
  - Volume (V)
- Trigger Event (What starts inspiration)
  - Patient
  - Ventilator
- Breath Classification
  - Spontaneous
  - Mandatory
- Breath Sequence
  - Continuous Mandatory Ventilation (CMV) (AKA assist/control)
  - Intermittent Mandatory Ventilation (IMV)
  - Continuous spontaneous ventilation (CSV)

## Volume Controlled Modes

- *Tidal volume* is set
- Peak inspiratory pressure (PIP) is variable
  - Dependent on lung compliance and resistance in the patient airways, tube, and the circuit
  - Monitor PIP closely, record at least q 4 hours

### Volume CMV or A/C and Volume IMV

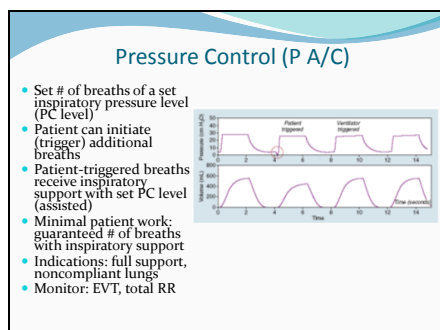
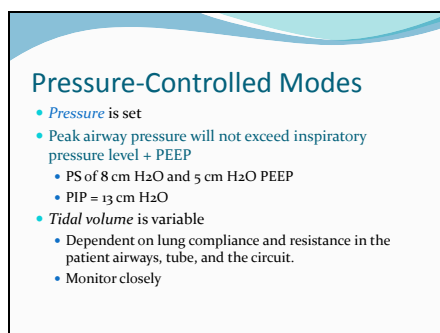
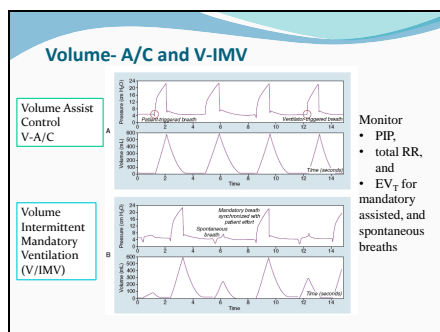
Set number of breaths of a set  $V_T$   
Patient can trigger additional breaths  
Guaranteed VT and minute ventilation

Volume Continuous Mandatory Ventilation (V-CMV) or Assist Control (V-A/C)

- Patient triggered breaths are assisted and receive the mandatory  $V_T$
- Minimal work for patient
- Possible hyperventilation with high RR

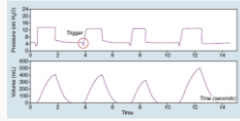
Volume Intermittent Mandatory Ventilation (V-IMV)

- Patient triggered breaths are spontaneous
- $V_T$  is whatever patient is capable of generating
- Allows patient to contribute to work-of-breathing (WOB)
  - Weaning mode



## Pressure Support (PS)

- Patient-triggers all breaths
- Patient's spontaneous breaths are augmented *on inspiration* by a pre-set amount of positive inspiratory pressure
- Indications: weaning, partial ventilatory support
- Monitor: PIP, total RR,  $EV_T$  (5 ml/kg), comfort, WOB,

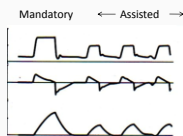


## Mini Clinical

- 55 year old two days status post major abdominal surgery for incarcerated bowel
- Ventilator settings:  $FiO_2$  .35, AC 10, PEEP 5, VT 550
- Passes all screening criteria for weaning.
- Switched to PS 5 over 5 PEEP
  - Why this mode?
  - How does this impact his WOB?
  - How long apply this mode?
  - How will we know if he is tolerating this mode change?

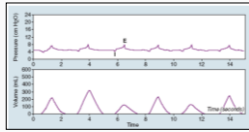
## Pressure Intermittent Mandatory Ventilation (P/IMV)

- Ventilator-triggered, mandatory breaths are P/AC
- Patient-triggered, spontaneous breaths are supported by either:
  - Second, lower level of PS
  - No support at all
- More work for patient than P/AC but less than PS alone



## Continuous Positive Airway Pressure (CPAP)

- Patient-triggered, spontaneous breathing with no assistance.
- Pressure applied at end-expiration, like PEEP
- Weaning mode
- Option for patients with sleep apnea
  - Nasal or face mask
- Monitor: RR, exhaled  $V_T$ , comfort, WOB



## Mini Clinical #1

- 62 year old male with history of CAD.
- CABG x 4
- Post op ventilator settings:  $FiO_2$  .5, AC 14, PEEP 5,  $V_T$  600
- 5 hours post-op passes screening for weaning
- Switched to CPAP 5
  - Why this mode?
  - How does this impact his WOB?
  - How will we know if he is tolerating this mode change?

## Mini Clinical #2

- 62 y/o male (WM) presents to the ED s/p rib pain x 2 weeks after fall in bathtub
- PMH: diabetes, difficulty checking his blood sugars, doesn't eat well, multiple falls
- Multiple rib fracture, large pleural effusion, CT placed with 1.5 L serosanguinous fluid out
- Purulent sputum, febrile
- RR 34, SBP 85
- 80 kg
- ABG: 7.25,  $PaCO_2$  55,  $PaO_2$  63, BD 7.0,  $HCO_3$  19,  $SaO_2$  89

# Intubation and Mech. Vent

- V- A/C, Rate 18, FiO<sub>2</sub> .6, PEEP 5, V<sub>T</sub> 500
- EV<sub>T</sub> = 467, PIP 48, Total RR = 27
- ABG: 7.29, PaCO<sub>2</sub> 42, PaO<sub>2</sub> 70, BD 6.0, HCO<sub>3</sub> 19, SaO<sub>2</sub> 92

- Why this mode?
  - Any issues?
- What do we do next? Options?

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  - Any issues?
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## Ventilator Changes

- P-A/C 35, rate 24, FiO<sub>2</sub> .9, PEEP 5
- EVT = 402, PIP 40, Total RR = 24
- ABG: 7.30, PaCO<sub>2</sub> 33, PaO<sub>2</sub> 251, BD 5.0, HCO<sub>3</sub> 21, SaO<sub>2</sub> 100

- What assessment findings are concerning?
- Options for improving ventilatory support?

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## Airway Pressure Release Ventilation (APRV)

- Provides two levels of CPAP
- Patient-trigger, spontaneous breathing allowed at any point in the respiratory cycle
- Starts at an elevated pressure (P<sub>high</sub> or P<sub>1</sub>), followed by a *release* pressure (P<sub>low</sub> or P<sub>2</sub>)
- Time on high pressure (T<sub>high</sub> or T<sub>1</sub>) is longer than low pressure time (T<sub>low</sub> or T<sub>2</sub>)
- Holds airways open, lung protective
- Improves oxygenation by increasing mean airway pressure

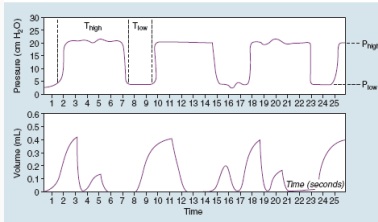
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## APRV

### Pressure and Time



## Next Steps with WM

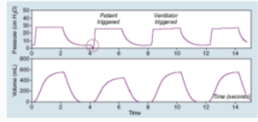
- Switch to APRV
- Three days later settings are:
  - Time high = 5      Time low = 0.7
  - Pressure high = 32      Pressure low = 0
  - This results in ??? # of releases
- Release EVT = 590, PIP 32, Total RR = 28
- ABG: 7.46, PaCO<sub>2</sub> 28, PaO<sub>2</sub> 137, BD 1.0, HCO<sub>3</sub> 22, SaO<sub>2</sub> 99
- How do you manage respiratory alkalosis with APRV?

## Adjusting the Vent to Correct ABG Abnormalities

- Oxygenation (PaO<sub>2</sub>)
  - FiO<sub>2</sub>
  - PEEP
    - Pressure Mode: Increase mean airway pressure (mPaw)
- Ventilation (PaCO<sub>2</sub>)
  - Tidal volume (VT)
    - Pressure Mode: Increase or decrease Delta P
  - Respiratory rate

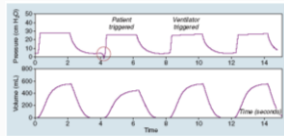
Patient on pressure control of 24, PEEP 5, FIO<sub>2</sub> .6, rate of 20.  
Total RR is 22. ABG reveals respiratory alkalosis and acceptable oxygenation. You anticipate the following change in the ventilator settings:

- Increase PC to 32
- Decrease PC to 22
- Increase rate to 24
- Increase PEEP to 10

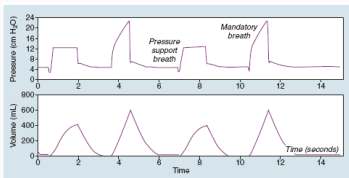


Patient on pressure control of 18, PEEP 5, FIO<sub>2</sub> .8, rate of 20. Total RR is 20. ABG reveals pH 7.46, PaO<sub>2</sub> 57, PaCO<sub>2</sub> 34, SaO<sub>2</sub> 88%. You anticipate the following change in the ventilator settings:

- Increase PC to 22
- Decrease PC to 16
- Increase rate to 24
- Increase PEEP to 12



### Combining Modes: SIMV + Pressure Support

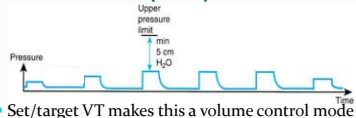


How does this differ from SIMV alone?

## Dual Control Modes:

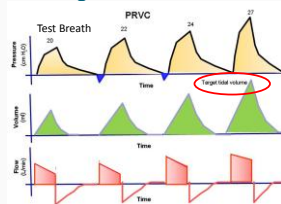
- Use both control variables:
  - Pressure (P)
  - Volume (V)
- Breath scheme allows the ventilator to switch between volume and pressure control variables *during a single inspiration*
  - Pressure-regulated Volume Control (PRVC)
    - CMV + Assist
  - Volume support (VS)

## Dual Control Mode: Pressure Regulated Volume Control (PRVC)



- Set/target VT makes this a volume control mode
- Set rate
- Ventilator controls/adjusts *inspiratory pressure*
  - in response to the lung compliance
  - to deliver the target VT
  - using the lowest possible pressure.

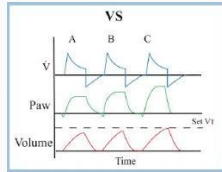
## Pressure Regulated Volume Control



Monitor PIP to assess amount of pressure required to achieve desired VT.

## Volume Support

- Set/target VT makes this a volume control mode
- Patient-triggered, spontaneous breaths
- Ventilator controls/adjusts *inspiratory pressure*
  - in response to the lung compliance
  - to deliver the target VT
  - using the lowest possible pressure.



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