

## Mechanical Ventilation

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Which of the following is true regarding ventilation?

- A. Normal inspiratory muscle strength is approx 50 cm H<sub>2</sub>O
- B. Normal tidal volume is 500 ml
- C. Normal physiology uses negative pressure inspiration
- D. Ventilators mimic normal physiology

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## Basics of Ventilation

- Normally use negative pressure for inspiration
- Positive pressure (passive) for exhalation
- Ventilators use positive pressure (active) for inspiration



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### Some Normal Physiology

- Tidal Volume ( $V_t$ ) 5 ml/kg
- Minute Ventilation ( $V_e$ ) <10-12/min
- Negative Insp Force (NIF) < -100
- Resp Rate <16 (the 20 on all charts is actually tachypnea!!!)

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### Some History

- Ventilators in the ICU are relatively new
  - Used only in surgery prior
    - No post-operative usage
  - “Iron Lungs” were neg pressure devices
  - Modern ventilators developed in the 1950’s

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Which of the following is true regarding ventilator modes?

- A. In a control mode the patient initiates the breath
- B. In assist mode the patient initiates the breath
- C. In SIMV the ventilator gives a full breath each time the patient initiates a breath
- D. In pressure assist-control the machine guarantees a tidal volume

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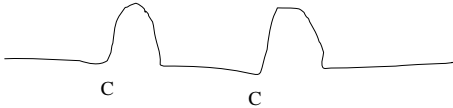
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## Settings

- Initial ventilators: Pressure Cycled
  - Set a rate, and pressure
  - Volume unknown
- Initial mode: Control: Machine initiates breath



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## Settings

- Subsequent ventilators: Volume-cycled
  - Set a tidal volume and rate

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## Early Weaning

- Control to T-Piece: Extubate if can breathe
  - All or None
  - Probs with ventilator synchrony
  - Led to new modes

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## Vent Modes

- Assist Breath
  - Senses the negative pressure of normal ventilation
  - Machine cycles and gives a full breath (pressure or volume)




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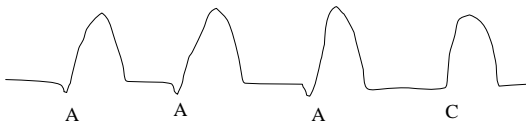
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## Assist-Control: Full Support

- Will assist if spontaneously triggering
- Control as a backup if apneic (at set rate)
- Machine gives a full breath each time
  - Pt breathes 30/min: gets 30 breaths
- Can be regulated by pressure or volume




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## Assist-Control

<b>Mode</b>	<b>Initiate</b>	<b>Regulate</b>	<b>Cycle</b>	<b>Interaction</b>
Vol A-C	Pt or Time	Volume	Vol	1:1 with backup
Press A-C	Pt or Time	Pressure	Time	1:1 with backup

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## Early Weaning

- Assist-Control to T-Piece
  - Extubate if can breathe
  - Not scientific
  - Theory that partial reduction of ventilation would help

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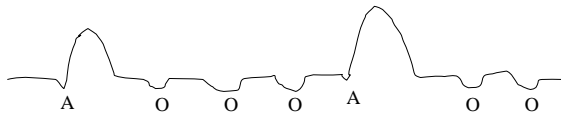
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## (S)IMV

- IMV: Intermittent Mandatory Ventilation
  - Give only a set amount of breaths per minute
  - Rest on their own
  - Start with A-C; switch to IMV and gradually reduce rate
- SIMV: Synchronized



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## SIMV Pitfalls

- Rate is all you get (vs A-C)
- Own breaths through ETT, vent tubing, valves in the circuit, etc.
- Lot's of vent dyssynchrony

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## SIMV Modes

<u>Mode</u>	<u>Initiate</u>	<u>Regulate</u>	<u>Cycle</u>	<u>Interaction</u>
Vol SIMV	Pt or Time	Volume	Vol	1:1 at set rate
Press SIMV	Pt or Time	Pressure	Time	1:1 at set rate

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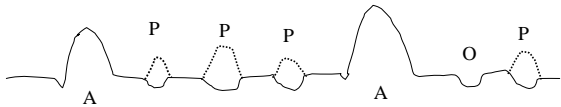
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## Pressure Support

- Set amount of pressure added to own breaths; limited by a decrease in flow
- Initially used in conjunction with SIMV
  - Now used alone for wean or ventilation
- Effort determines Vt




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## Pressure Support

<u>Mode</u>	<u>Initiate</u>	<u>Regulate</u>	<u>Cycle</u>	<u>Interaction</u>
PSV	Pt	Pressure	Flow	1:1

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### Ventilator Modes

Mode	Settings	Limits	Advant	Disadvant
Vol A-C				
Vol SIMV				
Press A-C				
Press SIMV				
PSV				

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### Ventilator Modes

Mode	Settings	Limits	Advant	Disadvant
Vol A-C	RR, Vi, FIO2, PEEP, Flow			
Vol SIMV				
Press A-C				
Press SIMV				
PSV				

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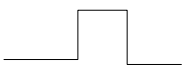
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### Flow in Volume Modes

- Generally Constant
- Pressure “ramps up” as flow continues
- Some pts not tolerant; need higher flow earlier in duty cycle



Flow



Pressure

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### Ventilator Modes

Mode	Settings	Limits	Advant	Disadvant
Vol A-C	RR, Vt, FIO <sub>2</sub> , PEEP, Flow			
Vol SIMV				
Press A-C				
Press SIMV				
PSV				

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### Ventilator Modes

Mode	Settings	Limits	Advant	Disadvant
Vol A-C	RR, Vt, FIO <sub>2</sub> , PEEP, Flow	Reach Vt		
Vol SIMV				
Press A-C				
Press SIMV				
PSV				

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### Ventilator Modes

Mode	Settings	Limits	Advant	Disadvant
Vol A-C	RR, Vt, FIO <sub>2</sub> , PEEP, Flow	Reach Vt	Guarant Vt	
Vol SIMV				
Press A-C				
Press SIMV				
PSV				

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### Ventilator Modes

Mode	Settings	Limits	Advant	Disadvant
Vol A-C	RR, Vt, FIO2, PEEP, Flow	Reach Vt	Guarant Vt	No press limit
Vol SIMV				
Press A-C				
Press SIMV				
PSV				

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### Ventilator Modes

Mode	Settings	Limits	Advant	Disadvant
Vol A-C	RR, Vt, FIO2, PEEP, Flow	Reach Vt	Guarant Vt	No press limit
Vol SIMV	Same			
Press A-C				
Press SIMV				
PSV				

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### Ventilator Modes

Mode	Settings	Limits	Advant	Disadvant
Vol A-C	RR, Vt, FIO2, PEEP, Flow	Reach Vt	Guarant Vt	No press limit
Vol SIMV	Same	Same		
Press A-C				
Press SIMV				
PSV				

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### Ventilator Modes

Mode	Settings	Limits	Advant	Disadvant
Vol A-C	RR, Vt, FIO2, PEEP, Flow	Reach Vt	Guarant Vt	No press limit
Vol SIMV	Same	Same	??	
Press A-C				
Press SIMV				
PSV				

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### Ventilator Modes

Mode	Settings	Limits	Advant	Disadvant
Vol A-C	RR, Vt, FIO2, PEEP, Flow	Reach Vt	Guarant Vt	No press limit
Vol SIMV	Same	Same	??	Rate is all you get
Press A-C				
Press SIMV				
PSV				

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### Volume Modes

- Volume Limited
- No Pressure limitation; can lead to lung injury

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## Ventilator Modes

Mode	Settings	Limits	Advant	Disadvant
Vol A-C	RR, Vt, FIO2, PEEP, Flow	Reach Vt	Guarant Vt	No press limit
Vol SIMV	Same	Same	??	Rate is all you get
Press A-C				
Press SIMV				
PSV				

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## Ventilator Modes

Mode	Settings	Limits	Advant	Disadvant
Vol A-C	RR, Vt, FIO2, PEEP, Flow	Reach Vt	Guarant Vt	No press limit
Vol SIMV	Same	Same	??	Rate is all you get
Press A-C	RR, Press, FIO2, PEEP, Insp%			
Press SIMV				
PSV				

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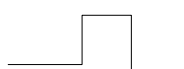
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## Flow in Pressure Modes

- Decelerating
  - High early in inspiration
  - Early, constant pressure
  - Easier titration of insp times



Flow



Pressure

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### Ventilator Modes

Mode	Settings	Limits	Advant	Disadvant
Vol A-C	RR, Vt, FIO2, PEEP, Flow	Reach Vt	Guarant Vt	No press limit
Vol SIMV	Same	Same	??	Rate is all you get
Press A-C	RR, Press, FIO2, PEEP, Insp%			
Press SIMV				
PSV				

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### Ventilator Modes

Mode	Settings	Limits	Advant	Disadvant
Vol A-C	RR, Vt, FIO2, PEEP, Flow	Reach Vt	Guarant Vt	No press limit
Vol SIMV	Same	Same	??	Rate is all you get
Press A-C	RR, Press, FIO2, PEEP, Insp%	Insp Time		
Press SIMV				
PSV				

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### Ventilator Modes

Mode	Settings	Limits	Advant	Disadvant
Vol A-C	RR, Vt, FIO2, PEEP, Flow	Reach Vt	Guarant Vt	No press limit
Vol SIMV	Same	Same	??	Rate is all you get
Press A-C	RR, Press, FIO2, PEEP, Insp%	Insp Time	Decel Flow, Press Limit	
Press SIMV				
PSV				

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### Ventilator Modes

Mode	Settings	Limits	Advant	Disadvant
Vol A-C	RR, Vt, FIO2, PEEP, Flow	Reach Vt	Guarant Vt	No press limit
Vol SIMV	Same	Same	??	Rate is all you get
Press A-C	RR, Press, FIO2, PEEP, Insp%	Insp Time	Decel Flow, Press Limit	No Guarant Vt
Press SIMV				
PSV				

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### Ventilator Modes

Mode	Settings	Limits	Advant	Disadvant
Vol A-C	RR, Vt, FIO2, PEEP, Flow	Reach Vt	Guarant Vt	No press limit
Vol SIMV	Same	Same	??	Rate is all you get
Press A-C	RR, Press, FIO2, PEEP, Insp%	Insp Time	Decel Flow, Press Limit	No Guarant Vt
Press SIMV	Same			
PSV				

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### Ventilator Modes

Mode	Settings	Limits	Advant	Disadvant
Vol A-C	RR, Vt, FIO2, PEEP, Flow	Reach Vt	Guarant Vt	No press limit
Vol SIMV	Same	Same	??	Rate is all you get
Press A-C	RR, Press, FIO2, PEEP, Insp%	Insp Time	Decel Flow, Press Limit	No Guarant Vt
Press SIMV	Same	Same		
PSV				

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### Ventilator Modes

Mode	Settings	Limits	Advant	Disadvant
Vol A-C	RR, Vt, FIO2, PEEP, Flow	Reach Vt	Guarant Vt	No press limit
Vol SIMV	Same	Same	??	Rate is all you get
Press A-C	RR, Press, FIO2, PEEP, Insp%	Insp Time	Decel Flow, Press Limit	No Guarant Vt
Press SIMV	Same	Same	??	
PSV				

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### Ventilator Modes

Mode	Settings	Limits	Advant	Disadvant
Vol A-C	RR, Vt, FIO2, PEEP, Flow	Reach Vt	Guarant Vt	No press limit
Vol SIMV	Same	Same	??	Rate is all you get
Press A-C	RR, Press, FIO2, PEEP, Insp%	Insp Time	Decel Flow, Press Limit	No Guarant Vt
Press SIMV	Same	Same	??	Rate is all you get
PSV				

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### Pressure Assist/SIMV Modes

- Time Limited
- Decelerating Flow
  - Easier titration of insp times
  - Better patient tolerance early in duty cycle

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### Ventilator Modes

Mode	Settings	Limits	Advant	Disadvant
Vol A-C	RR, Vt, FIO2, PEEP, Flow	Reach Vt	Guarant Vt	No press limit
Vol SIMV	Same	Same	??	Rate is all you get
Press A-C	RR, Press, FIO2, PEEP, Insp%	Insp Time	Decel Flow, Press Limit	No Guarant Vt
Press SIMV	Same	Same	??	Rate is all you get
PSV				

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### Ventilator Modes

Mode	Settings	Limits	Advant	Disadvant
Vol A-C	RR, Vt, FIO2, PEEP, Flow	Reach Vt	Guarant Vt	No press limit
Vol SIMV	Same	Same	??	Rate is all you get
Press A-C	RR, Press, FIO2, PEEP, Insp%	Insp Time	Decel Flow, Press Limit	No Guarant Vt
Press SIMV	Same	Same	??	Rate is all you get
PSV	RR, Press, FIO2, PEEP			

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### Ventilator Modes

Mode	Settings	Limits	Advant	Disadvant
Vol A-C	RR, Vt, FIO2, PEEP, Flow	Reach Vt	Guarant Vt	No press limit
Vol SIMV	Same	Same	??	Rate is all you get
Press A-C	RR, Press, FIO2, PEEP, Insp%	Insp Time	Decel Flow, Press Limit	No Guarant Vt
Press SIMV	Same	Same	??	Rate is all you get
PSV	RR, Press, FIO2, PEEP	Flow		

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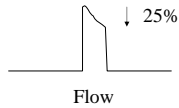
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## PSV: Flow Limited

- Standard: Drop of Insp flow by 25%
  - Newer ventilators allow adjustment
- Allows pt to continue inspiration
  - In pressure modes shut off by reaching insp time
  - In volume modes shut off by reaching Vt




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## Ventilator Modes

Mode	Settings	Limits	Advant	Disadvant
Vol A-C	RR, Vt, FIO <sub>2</sub> , PEEP, Flow	Reach Vt	Guarant Vt	No press limit
Vol SIMV	Same	Same	??	Rate is all you get
Press A-C	RR, Press, FIO <sub>2</sub> , PEEP, Insp%	Insp Time	Decel Flow, Press Limit	No Guarant Vt
Press SIMV	Same	Same	??	Rate is all you get
PSV	RR, Press, FIO <sub>2</sub> , PEEP	Flow		

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## Ventilator Modes

Mode	Settings	Limits	Advant	Disadvant
Vol A-C	RR, Vt, FIO <sub>2</sub> , PEEP, Flow	Reach Vt	Guarant Vt	No press limit
Vol SIMV	Same	Same	??	Rate is all you get
Press A-C	RR, Press, FIO <sub>2</sub> , PEEP, Insp%	Insp Time	Decel Flow, Press Limit	No Guarant Vt
Press SIMV	Same	Same	??	Rate is all you get
PSV	RR, Press, FIO <sub>2</sub> , PEEP	Flow	Variable Vt, Pt comfort	

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## Ventilator Modes

Mode	Settings	Limits	Advant	Disadvant
Vol A-C	RR, Vt, FIO <sub>2</sub> , PEEP, Flow	Reach Vt	Guarant Vt	No press limit
Vol SIMV	Same	Same	??	Rate is all you get
Press A-C	RR, Press, FIO <sub>2</sub> , PEEP, Insp%	Insp Time	Decel Flow, Press Limit	No Guarant Vt
Press SIMV	Same	Same	??	Rate is all you get
PSV	RR, Press, FIO <sub>2</sub> , PEEP	Flow	Variable Vt, Pt comfort	No Vt or rate

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## Hybrid Modes

- Pressure-Regulated Volume Control
  - Decel Flow, Press Limited; Guarant Vt
  - Machine adjusts flow to target insp time
- Volume Support (Volume-Assured Pressure Support)
  - PSV mode, Guarant Vt; machine adjusts flow to meet the minimum Vt; pt may over breathe

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Which one of the following is true regarding oxygenation?

- A. Prone position improves mortality
- B. Inverse ratio improves mortality
- C. PEEP has no adverse hemodynamic consequences, especially at high levels
- D. PEEP is more likely to be helpful in pulmonary edema than pneumonia

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## Oxygenation

- FIO<sub>2</sub>
  - High levels can induce toxicity
  - Goal is as low as possible
- PEEP
  - Pressure left intrathoracic after exhalation
  - Allows for recruitment of alveoli
  - **Bilateral** processes
  - High levels can cause cardiac compromise

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## Ways to Improve Oxygenation

- Increasing FIO<sub>2</sub>
- Increasing PEEP
- Increasing Insp Time
  - Inverse Ratio: >50% Insp time
    - Rarely Used; Hemodynamic Problems
- Pronation
  - Improves Oxygenation
  - No effect on mortality

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## Hybrid Modes

- Airway Pressure Release Ventilation
  - Two levels of PEEP with intermittent release
- High Frequency Oscillatory Ventilation
  - Very high rates with minimal tidal volume; convection of airflow
  - Rarely used; no supportive clinical data

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Which of the following is true regarding weaning from mechanical ventilation?

- A. A person with a resp rate of 20 and a Vt of 400 ml is likely to wean
- B. A person with a resp rate of 30 and Vt of 200 is likely to wean
- C. IMV weaning modes shorten duration of mechanical ventilation
- D. Adding pressure support to IMV does not shorten time of mechanical ventilation

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### When Do I Wean?

- Clinically Ready!!!
- Adeq pulm reserve
  - Adeq weaning parameters
  - F/Vt (<104 predictive of successful wean)

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### Progression of Weaning Trials

- A-C to T-Piece
- SIMV
- SIMV and PSV
- PSV
- 1 Fastest Wean (Initial Trial)
- 4 Increased WOB
- 3
- 2 Fastest in 2<sup>nd</sup> Trial

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## Weaning: General Principles

- Full Support when initiating
  - PRVC, Vol A-C, Press A-C
- Daily Assessment of Weaning
  - SBT (Assess F/Vt)
  - “T-Piece Equivalent” (PSV)
  - If not ready to extubate
    - Full Support
    - Higher level PSV

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## Summary

- Many modes are available to use
- Patient comfort is of utmost importance
- Clear the acute process prior to aggressive weaning
- It is still an art!!!

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