Lung Protective Ventilation

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Why this talk?

- VILI – VILI is an acute lung injury affecting the airways and parenchyma that is caused by or exacerbated (induced) by mechanical ventilation.
- VALI – In clinical practice, it is often difficult to determine if the lung injury that a patient has developed was caused by the ventilatory pattern or was due to the patient's worsening (associated with) underlying lung condition. As such, the term VALI is often used if a causative relationship between lung injury and the mechanical ventilator cannot be proven

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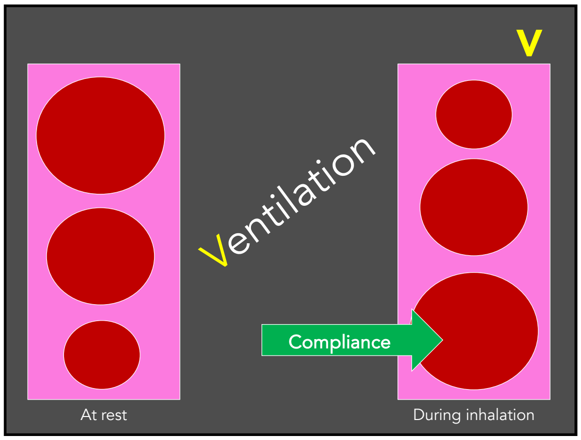

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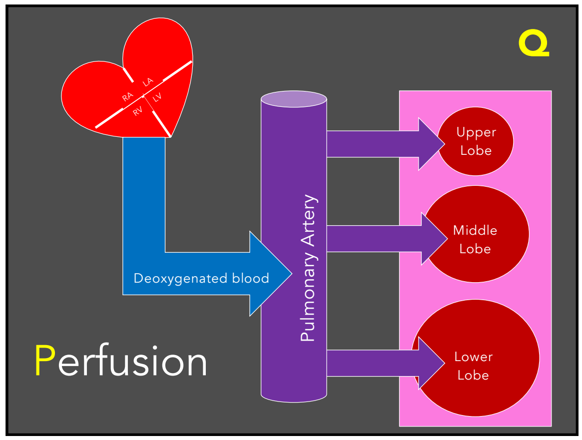

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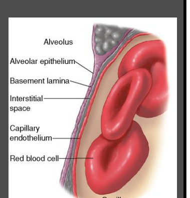
A:a gradient

- Alveolar-arterial oxygen gradient (**A-a gradient, for short**) is one way to assess the integrity of the alveolar-capillary unit and help determine the cause of a person's low PaO2



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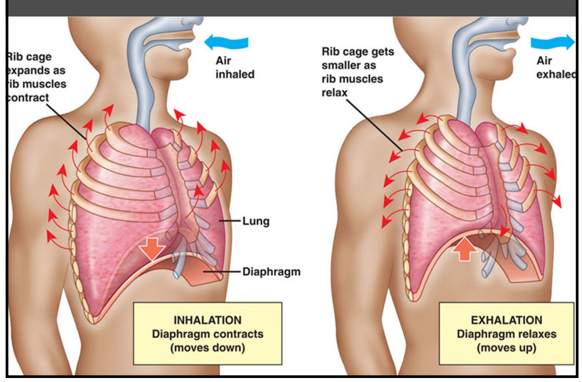
Ventilation -Mechanical



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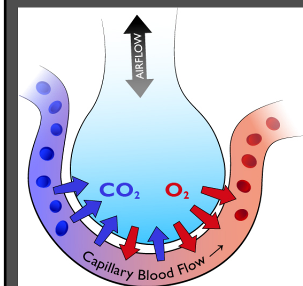
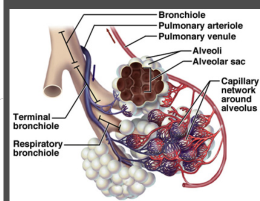
Perfusion- Chemical





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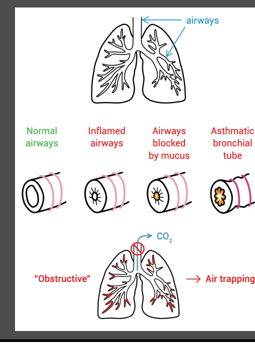
Airway Diseases

- Ventilation problem
- High CO_2
- Common diseases
  - COPD
  - Asthma
  - Bronchiectasis



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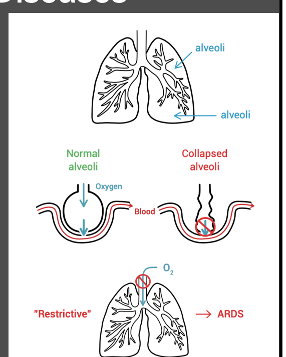
Alveolar Diseases

- Oxygenation problem
- Low PaO_2
- Common diseases
  - ARDS
  - Pulmonary fibrosis
  - Chest wall disease
  - Neuromuscular disease



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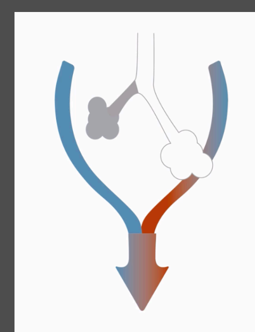
Pulmonary Shunting

- Caused by mechanical loss of alveolar integrity
- No participation in gas exchange

Easiest fix is increasing mean airway pressure



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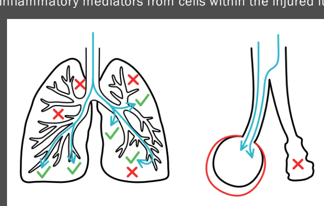
Volutrauma/Barotrauma/Biotrauma

- **Volutrauma - Alveolar overdistension (volutrauma)** — Volutrauma represents lung injury caused as lung units are overdistended with increased transpulmonary pressure
- **Atelectrauma** — cyclic alveolar expansion (during inspiration) and collapse (during expiration) creates shear forces that distend and cause injury to adjacent alveoli and lung tissue. N
- **Biotrauma (inflammation)** — Biotrauma is characterized by ventilator-induced release of inflammatory mediators from cells within the injured lung



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Ventilator basics

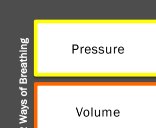
Standard settings

- Volume (amount)
- Pressure (force)
- Rate (frequency)
- Flow (speed)
- PEEP (tension)
- FiO_2 (% oxygen)

PV=nRT

Controlling

- Patient controlled
- Patient triggered
- Ventilator controlled
- Ventilator supported



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Cool Analogy

Mechanical Ventilator Breaths & Pull-Ups

Controlled Breath	Assisted Breath	Supported Breath
No Work	Start Work	Able to do Some or Most of Work
Ventilator Does All the Work	Ventilator Takes Over Work	Ventilator Assists to Finish Work (i.e. Pressure Support)

Frank Lodeserto MD, "Simplifying Mechanical Ventilation – Part I: Types of Breaths", REBEL EM blog, March 8, 2018. Available at: https://rebelem.com/simplifying-mechanical-ventilation-part/.

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Mechanical Ventilator Breaths:

- Controlled Breaths: These breaths are completely controlled by the ventilator. controlled breaths are delivered for safety. 100% of breathing comes from the ventilator
  - at a set time interval
    - patient is paralyzed
    - No respiratory drive (sedation, comatose, etc)

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Mechanical Ventilator Breaths:

- Assisted Breaths: assisted breaths on a ventilator.
  - Assist breaths will be delivered to your patient if they attempt to trigger a breath.
    - If your patient attempts a breath then the ventilator will sense this, and deliver a full mechanical breath
    - the patient must trigger the ventilator (sucking in on ETT and generate a change in pressure or flow), then the ventilator completely takes over and delivers a full breath.

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Mechanical Ventilator Breaths:

- Supported (Spontaneous) Breaths: These types of breaths are triggered by patient effort (like assisted breaths), but once triggered the ventilator will give you some support, but not full support like an assisted breath.

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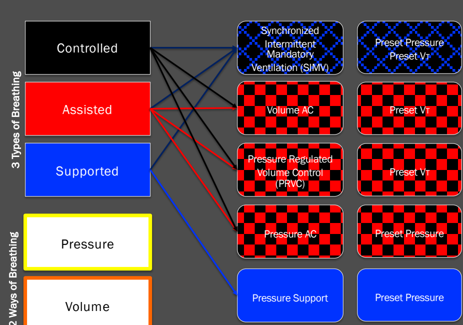
Ventilator Basics



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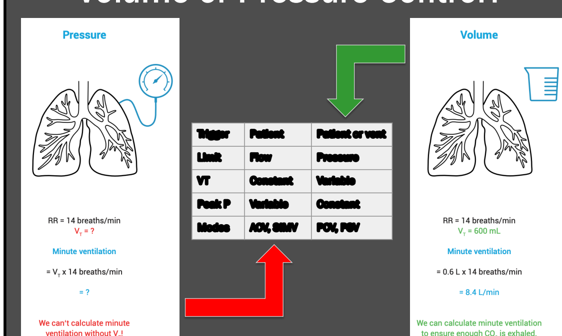
Volume or Pressure Control?



Trigger	Patient	Patient or vent
Limit	Flow	Pressure
VT	Constant	Variable
Peak P	Variable	Constant
Modes	ACV, SIMV	PCV, PSV

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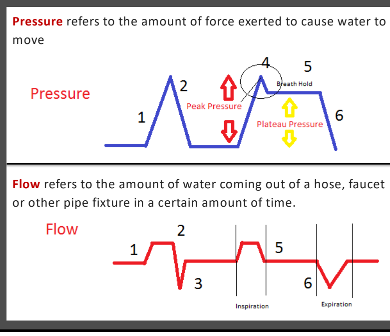
Ventilator diagram basics



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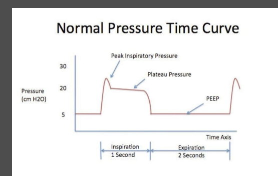
Peak and Plateau Pressures

Peak Pressure elevators
- Vent circuit
- Tube problems
- Bronchospasm
- Alveolar damage

Plateau Pressure elevators
- Only lung and alveolar pressures
  - No vent circuit
  - No ETT
  - No airway volumes



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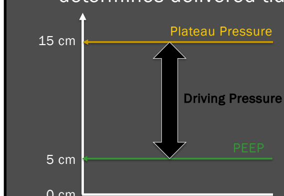
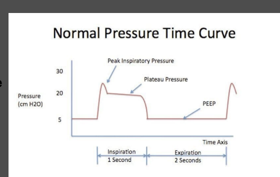
Driving pressures

- key ventilatory variable determining outcome
- *drives* gas into the lungs with each breath determines delivered tidal volume.





driving pressure = plateau pressure - positive end-expiratory pressure PEEP

Chris Nickson MD, "Pressure versus Time Graph" LITFL EM blog, March 29, 2019. Available at: https://litfl.com/pressure-versus-time-graph/

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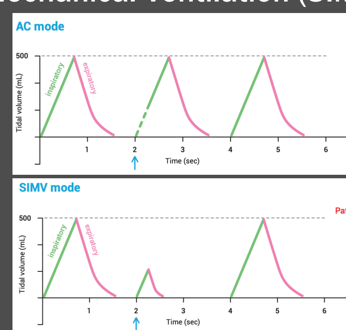
AC vs Synchronized intermittent Mechanical Ventilation (SIMV)



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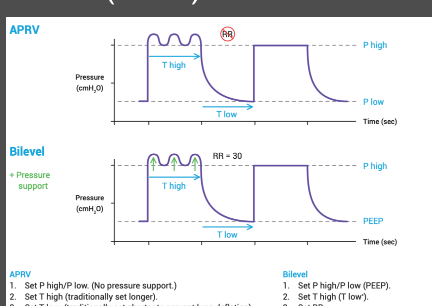
Airway Pressure Release Ventilation (APRV) vs Bilevel



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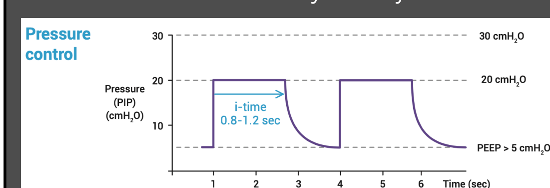
Pressure Control

- *Set i-time* may not match the patient's desired i-time – vent asynchrony?



Asynchrony?
1. Adjust i-time
2. Sedate patient
3. Change modes

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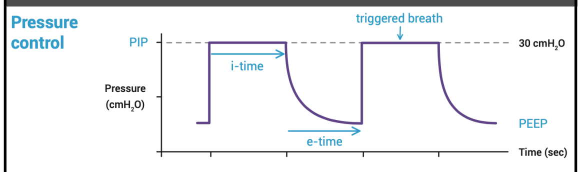
Pressure Control

- In pressure control mode, the V_T changes with lung compliance so you can easily monitor improvement in lung function.



Improved V_T means improved compliance

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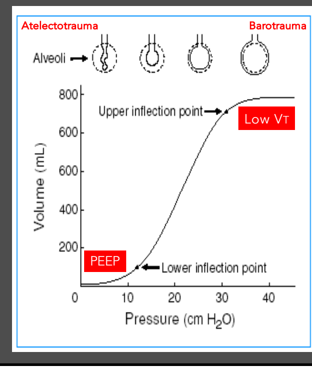
Ventilation strategies



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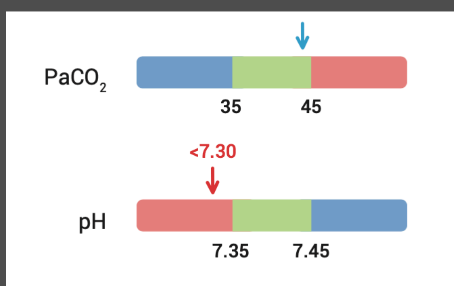
Permissive Acidosis



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ARDS specific ventilation

1. small tidal volumes (6 mL/kg predicted body weight) and
2. maintaining a plateau pressure of ≤30 cm

Airway Pressure Release Ventilation (APRV) *may* decrease the peak airway pressure, improve alveolar recruitment, increase ventilation of the dependent lung zones and improve oxygenation

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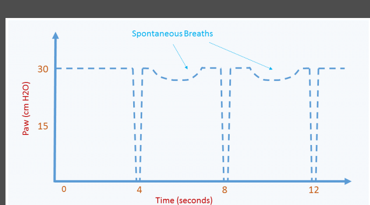
APRV (bi-level) settings?

- **P-High**
  - Transitioning from volume-cycled ventilation: set equal to plateau pressure.
  - Transitioning from pressure-cycled ventilation: set equal to peak pressure.
  - Often start ~25 cm.
- **P-Low**
  - Set to zero.
- **T-High**
  - Set to 5 seconds.
- **T-Low**
  - Set to 0.5 seconds initially.
  - Adjust to achieve an end-expiratory flow equal to 75% of the peak expiratory flow rate
- **FiO2**
  - Start high, titrate down ASAP.



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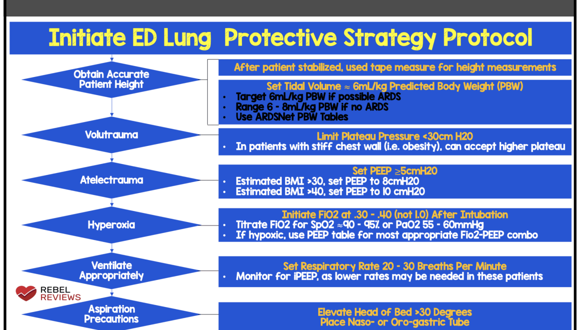

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