

# Lung Protective Ventilation

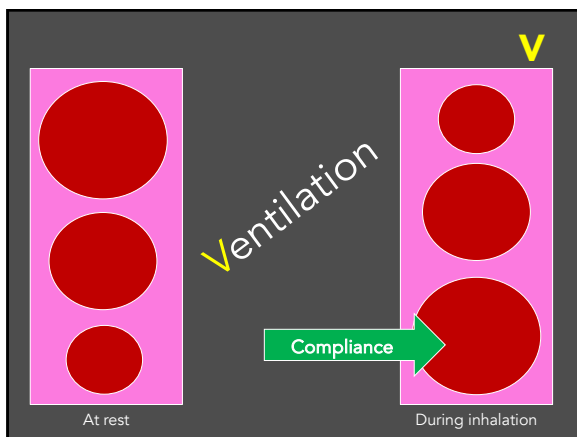
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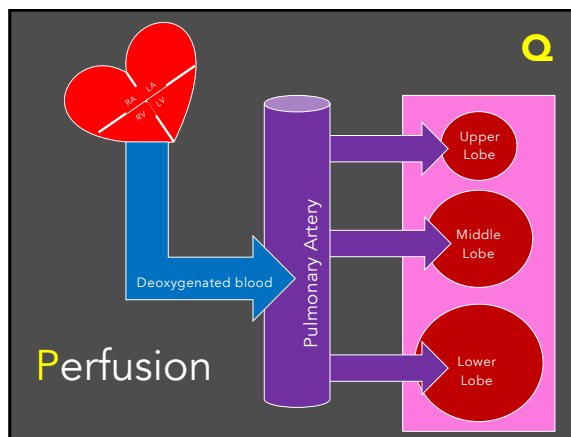
## Why this talk?

- **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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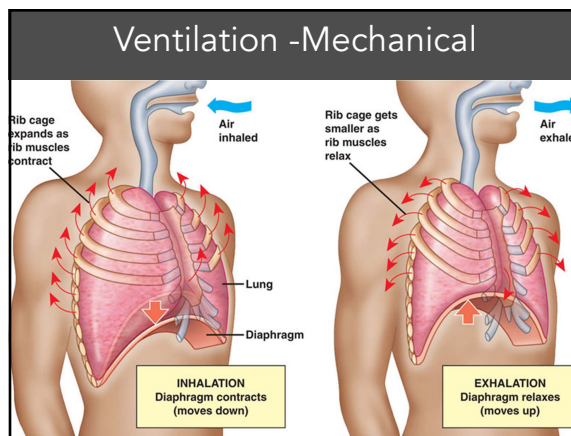


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## A:a gradient

- 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 PaO<sub>2</sub>

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### Perfusion- Chemical

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### Airway Diseases

- Ventilation problem
- High CO<sub>2</sub>
- Common diseases
  - COPD
  - Asthma
  - Bronchiectasis

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### Alveolar Diseases

- Oxygenation problem
- Low PaO<sub>2</sub>
- 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<sub>2</sub> (% oxygen)

**PV=nRT**

#### Controlling

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

2 Ways of Breathing

Pressure

Volume

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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-1/>

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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

3 Types of Breathing

2 Ways of Breathing

Controlled	Synchronized Intermittent Mandatory Ventilation (SIMV)	Preset Pressure, Preset VT
Assisted	Volume AC	Preset VT
Supported	Pressure Regulated Volume Control (PRVC)	Preset VT
Pressure	Pressure AP	Preset Pressure
Volume	Pressure Support	Preset Pressure

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### Volume or Pressure Control?

#### Pressure

RR = 14 breaths/min  
V<sub>t</sub> = ?

Minute ventilation  
= V<sub>t</sub> x 14 breaths/min  
= ?

We can't calculate minute ventilation without V<sub>t</sub>!

↓

↙

↘

↑

#### Volume

RR = 14 breaths/min  
V<sub>t</sub> = 600 mL

Minute ventilation  
= 0.6 L x 14 breaths/min  
= 8.4 L/min

We can calculate minute ventilation to ensure enough CO<sub>2</sub> is exhaled.

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

**Pressure** refers to the amount of force exerted to cause water to move

**Flow** refers to the amount of water coming out of a hose, faucet or other pipe fixture in a certain amount of time.

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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 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

**APRV**

1. Set P high/P low. (No pressure support)
2. Set T high. (traditionally set longer).
3. Set T low. (traditionally set shorter to prevent lung deflation).

**Bilevel**

1. Set P high/P low (PEEP).
2. Set T high (T low).
3. Set RR.

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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

- small tidal volumes (6 mL/kg predicted body weight) and
- maintaining a plateau pressure of  $\leq 30$  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
- FI<sub>O2</sub>**
  - Start high, titrate down ASAP.

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### Initiate ED Lung Protective Strategy Protocol

**After patient stabilized, used tape measure for height measurements**

- Set Tidal Volume - 6mL/kg Predicted Body Weight (PBW)
  - Target 6mL/kg PBW if possible ARDS
  - Range 6 - 8mL/kg PBW if no ARDS
  - Use ARDSNet PBW Tables
- Limit Plateau Pressure  $\leq 30$ cm H<sub>2</sub>O
  - In patients with stiff chest wall (i.e. obesity), can accept higher plateau
- Set PEEP - 5cmH<sub>2</sub>O
  - Estimated BMI  $\geq 30$ , set PEEP to 8cmH<sub>2</sub>O
  - Estimated BMI  $\geq 40$ , set PEEP to 10 cmH<sub>2</sub>O
- Initiate FI<sub>O2</sub> at .30 - .40 (not 1.0) After Intubation
  - Titrate FI<sub>O2</sub> for SpO<sub>2</sub> 90 - 95% or PaO<sub>2</sub> 55 - 60mmHg
  - If hypoxic, use PEEP table for most appropriate FI<sub>O2</sub>-PEEP combo
- Set Respiratory Rate 20 - 30 Breaths Per Minute
  - Monitor for PEEP, as lower rates may be needed in these patients
- Elevate Head of Bed  $\geq 30$  Degrees
- Place Naso- or Oro-gastric Tube

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