Is Your Patient Breathing? Ventilation in the OR

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Disclaimer

- I have no actual or potential conflict of interest in relation to this program/presentation.

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Respiratory Physiology Ventilation

- **Inspiration:** Act of drawing air into the lungs, the contraction of muscles creating a reduced pressure in the chest causing lungs to expand and air to flow inward.
- **Expiration:** Act of breathing out or expelling air out of the lungs. The release of carbon dioxide from the body.
- **Oxygenation:** The addition of oxygen to any system. Specifically used to describe interventions that provide greater oxygen supply to the lungs and thus the circulation

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Ventilatory Drive

- Chemoreceptors
  - Carotid Bodies
    - Stimulated by a ↓ PaO2, ↓ pH, and hypoperfusion to the receptor.
    - Primarily Ventilatory Response
  - Aortic Bodies
    - Stimulated by a ↓ PaO2, and hypoperfusion to the receptor
    - Primarily Circulatory Response
  - Central Chemoreceptors
    - Medullary Centers
      - Located near Cranial Nerve IX and X
      - Stimulated by ↑ PaCO2, H+, and HCO3

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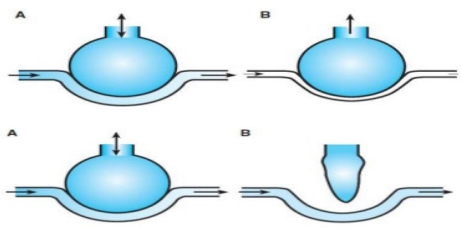
V/Q: What is the Mismatch?

- Ratio of Ventilation to Perfusion
- Physiology that leads to inability for oxygen to be delivered to the alveoli or decrease in perfusion leading to an inability of O2/CO2 exchange to take place in the pulmonary system.



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Conditions that lead to V/Q mismatch

- Decreased V/Q Mismatch
  - Asthma
  - Chronic Bronchitis
  - Pulmonary Edema
  - Airway obstruction
- Increased V/Q Mismatch
  - Pulmonary Embolism
  - Emphysema

No Ventilation but adequate perfusion

a. Shunt

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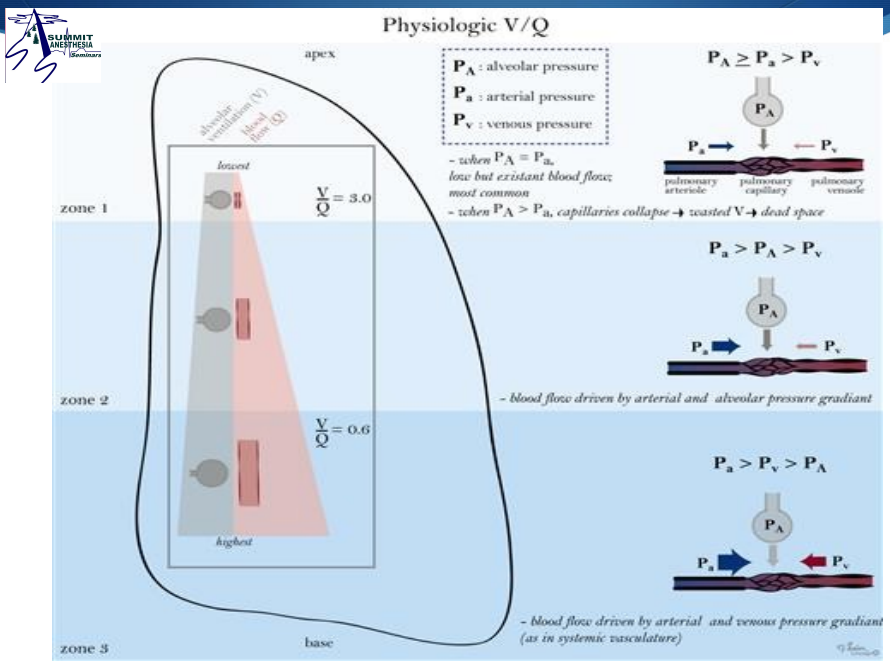

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Patient Positioning: Friend or Foe

- Trendelenburg:
  - Cephalad shift of abdominal contents
  - Decreased ability of the diaphragm to function
  - Ventilation Zone 3> Zone 2 > Zone 1
  - Decreased Compliance
- Reverse Trendelenburg
  - Increased Compliance
  - Caudad shift of abdominal contents
  - Ventilation Zone 1> Zone 2> Zone 3

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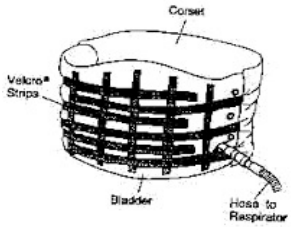
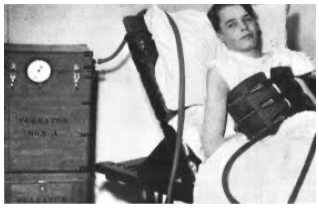
Ventilator History

- Intermittent Negative Pressure Ventilator

- Diaphragmatic Ventilator





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Ventilator: What is Inside?

- Bellows: GE (formerly Datex-Omeda)
  - Driving Gas compresses bellows forcing gas by vaporizers and into the patient.
  - Driving gas is usually oxygen, sometimes air
- Piston: Drager Apollo or Fabius GS
  - Do not require a driving gas
  - Electric Motor moves a piston thus creating pressure to move air into a patient's lungs
- Turbine: Drager Perseus
  - Electric motor drives a blower which creates inspiratory pressure and flow
  - Most efficient ventilator

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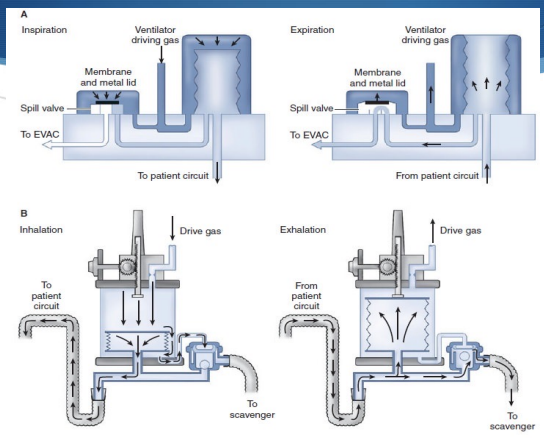
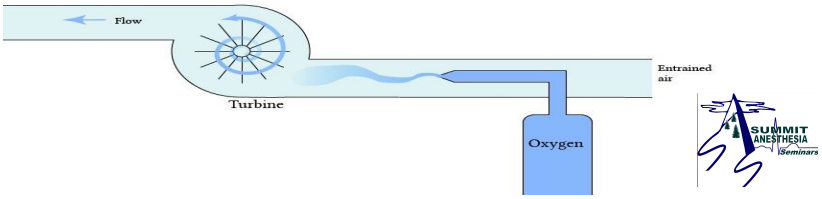


FIGURE 4–26 Double-circuit pneumatic ventilator design. A: Datex-Ohmeda. B: Dräger.



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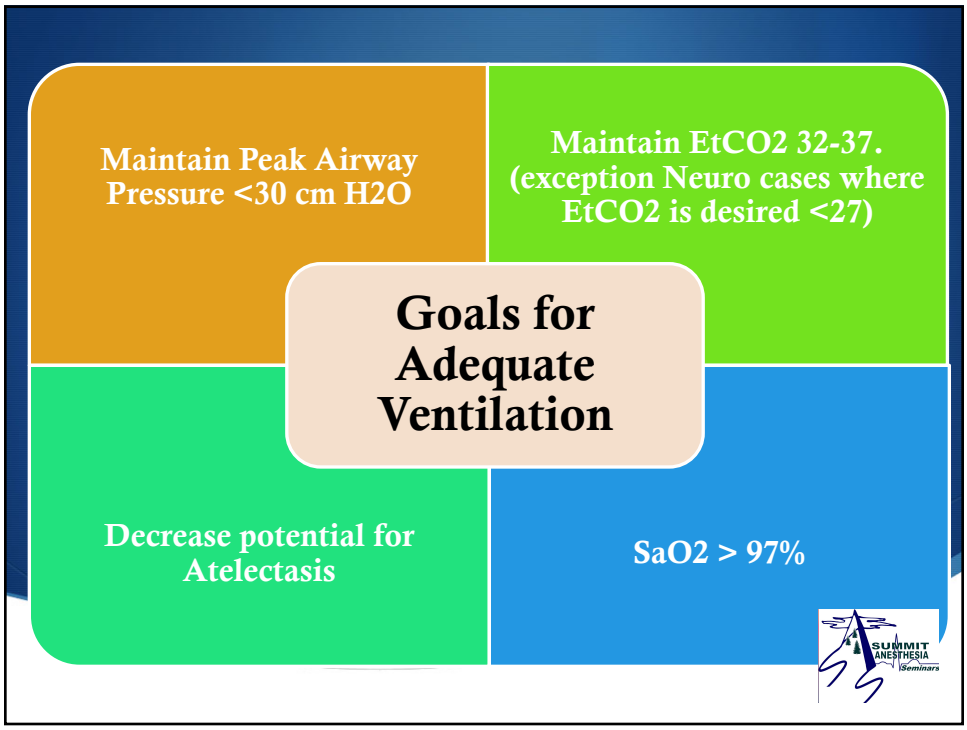

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Case Study #1

- 43 y/o F for Robotic Vaginal Hysterectomy w/BSO secondary to tumor
- PMHx:
  - BMI 48.2
  - Obstructive Sleep Apnea (CPAP at home)
  - HTN
  - NIDDM
- Position: Steep Trendelenburg
- Anesthesia: General Anesthesia
  - Paralyzed
  - ETT

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Mechanical Ventilation in the OR

- Positive Pressure Ventilator
- Used to adequately ventilate Patients
  - Decreased lung compliance
  - Increased airway Resistance
  - Absence of ventilation drive secondary to physiologic changes
- Multiple ventilation modes
- Computer-driven with active patient monitoring and feedback systems to enable adequate ventilation

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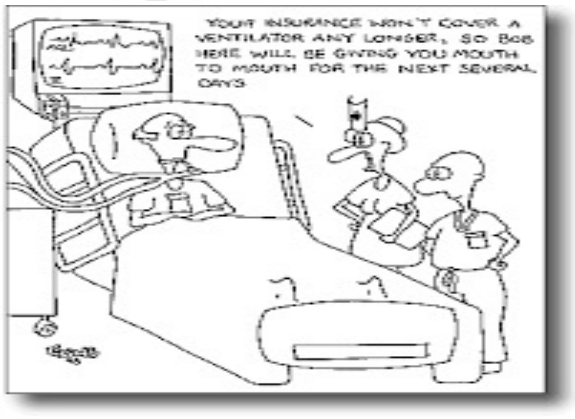
Why Do We Need Mechanical Ventilation?



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Reasons for Mechanical Ventilation

- Surgical Procedure
  - Intra-thoracic or Intra-abdominal
  - ENT
  - Muscle Relaxation required for adequate exposure or decreased risk of complication
- Inability to adequately oxygenate a patient
  - Patient physiology
  - Pulmonary disease
  - Patient position

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Anesthesia Machine Ventilator Modes

Volume Control
- Selected Specific Volume
- Rate Selected
- Independent of patient effort or response

Pressure Controlled
- Selected Pressure
- Variable Volume
- Rate Selected

SIMV
- Spontaneous Breaths allowed
- Preset Rate
- Preset Pressure

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Anesthesia Ventilator Modes (cont.)

Assist Control Ventilation

- Intermittent positive pressure
- Pt initiates ventilator to deliver a pre-determined tidal volume
- Back-up mode should patient be unable to initiate a breath

PSV: Pressure Support Ventilation

- Preset level of positive airway pressure
- Patient determines ventilatory rate
- Designed to increase the volume of the patient's spontaneous breath
- Decreases overall work of breathing especially diaphragmatic fatigue

PCV w/Volume Guaranteed Ventilation

- Preset Minute volume of gas either from a positive pressure breath or a spontaneous breath
- Preset mechanical rate and Inspiratory Pressure
- The goal is to have patients use more of their respiratory muscles

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Adjunct Ventilator Settings

- I:E
  - Ratio of Inspiration to Expiration
    - Time Inspired (PCV)
  - ↓PAP when using I:E to increase inspiratory time
  - ↑ expiratory time to allow adequate CO2 removal in COPD patient
  - Inverse Ratio Ventilation
- PEEP
  - Positive Pressure designed to keep alveoli open throughout the respiratory cycle.
  - Intrinsic vs. Extrinsic

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Hyperoxemia: Is it important?

- Suzuki, S. et al. Anesthesiology 2018: Randomized Study of 1786 patients
  - Results showed that in 92% of patients O2 was maintained between .32 and .6. 1% of patients had O2<.3 and 7% of patients had O2> .7
  - Of these patients 83% had hyperoxemia with 32% of patients having significant hyperoxemia
- Applegate, et al.: Intraoperative Hyperoxemia: An Unnecessary Evil
  - Mean PaO2 was 206mmHg with values up to 534mmHg of O2
  - Excessive O2 can lead to increase in reactive oxidative agents leading to cell damage, and dysfunction
  - Recommended to have O2 below 150mmHg

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Pressure Controlled Ventilation

- Volume is determined by preset pressure
- Time Triggered ventilatory cycle
- Ability to be delivered in IMV or ACV modes
- Has a decelerating flow pattern which improves distribution of gases
- Ideal for patient with decreased compliance due to
  - Body habitus
  - Pt position
  - Surgical Case

Must set Maximum Tidal Volume, especially laparoscopic cases!

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Ventilator GEM

- Pressure Control with Volume Guarantee (PCV-VG)
  - Volume and Pressure are preset
    - Preset Volume with a Max PAP!
  - Ventilator adjusts Pinsp to achieve preset TV breath by breath
  - Key Advantages:
    - Controlled Peak Inspiratory Pressure
    - Control of Minute Ventilation
    - Preset Volume delivered each breath at the minimum necessary pressure
  - Schick, V. Et al. Journal of Clinical Medicine(2021): PCV-VG provides benefits with respect to airway dynamics, and improved oxygenation in adults undergoing elective surgery

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SIMV

- Synchronized Intermittent Mandatory Ventilation:
  - Combination of ACV and Spontaneous Ventilation
- Baseline respiratory rate that allows patient to breath at their own rate between ventilator-initiated breaths
- Preset inspiratory pressure for intermittent mandatory breaths
- Ventilator attempts to synchronize mandatory breaths with patient-initiated breaths.
- PSV is used in conjunction with SIMV
  - Pt sets own respiratory rate with minimum pressure applied for each breath

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Assist Controlled Ventilation

- Intermittent positive-pressure ventilation mode in which the patient creates a sub-baseline pressure in the inspiratory limb which then triggers the ventilator to deliver a predetermined tidal volume
  - Back-up control mode should respiratory rate drop below a preset level
- Every breath is same volume whether patient initiates or the ventilator delivers
- Not for patients with a rapid respiratory rate

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What does the Research say?

- Gajic, et. al: Patients ventilated with TV >12% IBW were 25% more likely to have ALI or ARDS
- Choi et al.: Study noted that patients that were ventilated with 12 ml/kg at 5 hours showed significant procoagulant changes indicative of Acute Lung Injury when compared to Lung Volumes of 6ml/kg with 10cm PEEP
- Research done by the International Anesthesia Research Society shows PEEP increases intrathoracic pressure and the effects are amplified in patients suffering hypovolemia or cardiac dysfunction.. Does not recommend that SaO2 be used as an endpoint for PEEP

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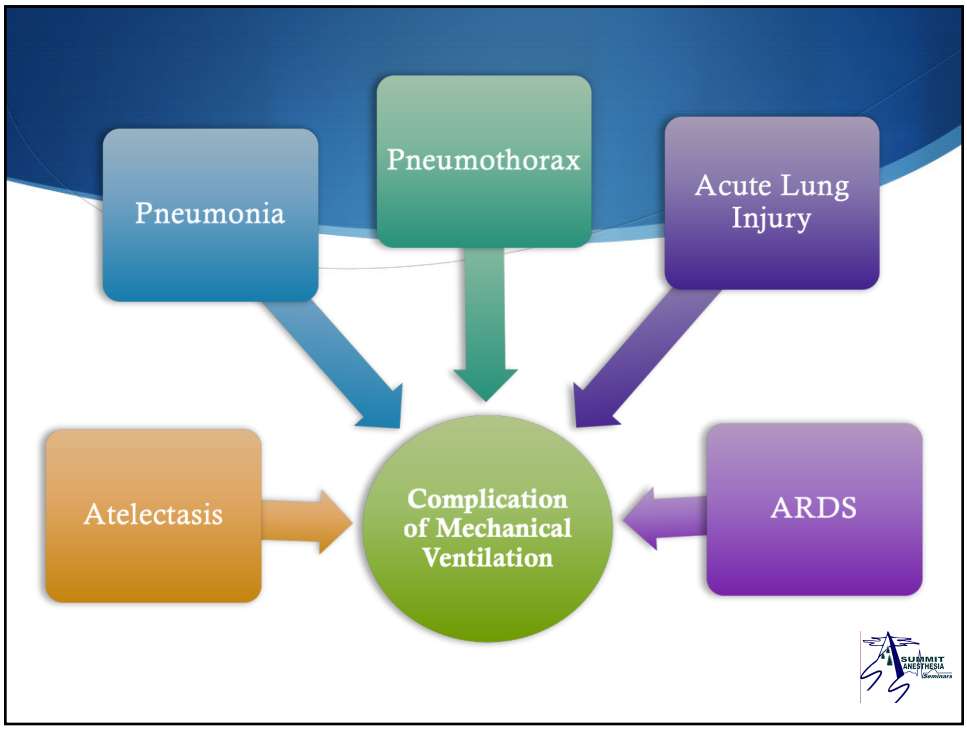

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Keys to overcoming Ventilatory Complications

- Pre-oxygenation
  - ↓ Hypoxia
  - ↑ FRC
  - ↓ Reabsorption Atelectasis
- Obesity
  - ↓ FRC
  - 37% of closed claims related to difficult intubation involved obese patients.
- Intermittent Alveolar Recruitment Breaths
- Essential that pre-oxygenation with a Facemask is practiced

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Pre-Existing Conditions that Compromise Ventilation

- COPD
  - Emphysema
  - Asthma
  - Chronic Bronchitis
- OSA
- Tracheal Stenosis
- Previous Lung Resection
- ARDS

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The "Not-So" wanted consequences

- Hypotension
  - Increased Intra-thoracic Pressure causing Decreased Venous Return
    - Positive Pressure Ventilation
    - Potentiated w/Insufflation for Laparoscopic Procedures
- ↓Cardiac Output
- Airway
  - Tracheal Scarring as a result of intubation
  - Negative Pressure Pulmonary Edema
  - Vocal Cord Damage

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COVID-19 and Ventilation

- Decreased Oxygenation
  - Pre-op O2 Saturation
  - Pre-Existing Pulmonary disorder
- PEEP: Too Much or Too Little?
  - Maintain adequate oxygenation
  - Decrease Barotrauma
- Spontaneous Pneumothorax
  - Be Vigilant

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Optimizing Ventilation

- Tidal Volume (6 – 8ml/kg) although lower volumes are ideal
- PEEP 5cm H2O to 10cm H2O
- Respiratory Rate
  - Maintain pCO2 32-37 (homeostatic state)
- Peak Airway Pressure < 30cm H2O
  - ARDS
  - Utilize I:E Ratio
- Intermittent Recruitment Breaths
  - Manually Insufflate to a PAP 40-50.
  - Every 30min.

Must be able to adapt for DECREASED Compliance and INCREASED Resistance

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What does the Research Say?

- Tsumara, H. et al., AANA Journal (2021): Despite all the advances in modes and methods of Ventilation, Post-op Pulmonary Complications remain one of the leading causes of adverse outcomes following surgery and anesthesia. Lung-protective ventilation usually entails the use of physiologic tidal volume, positive end expiratory pressure, extended inspiratory time, and alveolar recruitment
- Park, SJ et al., Surgery Endoscopy (2016): Protective Lung Ventilation (low-tidal volume with PEEP during pneumoperitoneum was associated with less instances of pulmonary complications than conventional ventilation

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Case Study #2

- 38 y/o M for Laparoscopic Robotic Gastric Bypass
- BMI 58.2
- PMHx:
  - HTN
  - NIDDM
  - OSA
  - Gout
- PSHx:
  - Appy
  - Cholecystectomy
  - Shoulder Arthroscopy
- What is your Anesthesia and Ventilation Plan?

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Case Study #2 (cont.)

- Position: Reverse Trendelenburg
- Endoscopy performed(? Surgeon Dependent)
- Induction:
  - Lidocaine
  - Propofol
  - Succinylcholine
  - Remifentanyl
    - (.75mcg/kg/min followed with a maintenance of 0.2mcg/kg/min)
  - Dilaudid
    - 1mg at the end of the procedure
- ERAS Protocol if surgeons are on board.
- Minimal Post-op Pain secondary to local anesthetic
- How are you going to ventilate this patient?

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PSV Pro "Unique to Anesthesia"

- Optimization of the spontaneously breathing patient
- Respiratory Rate driven by patient
  - Should patient not breath for a preset time (30sec) SIMV mode ventilation is initiated.
  - Protective mode with preset rate and pressure for SIMV mode
- Pressure supported breath to achieve adequate TV for each patient-initiated breath
- Research shows it is a superior mode to SIMV when weaning a patient from mechanical ventilation

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Summary

- Mechanical Ventilation is a standard of care in General Anesthesia
- Selection of Ventilation mode should be determined by
  - Surgical Case
  - Patient position
  - Pre-existing respiratory disease and function
  - Patient BMI
- Prevent atelectasis by using low TV and low PEEP.
- Do not be afraid to use different ventilator modes and I:E Ratio to maximize ventilation
- Intermittent Recruitment Breaths are extremely helpful

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Questions??

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