VENTILATION MODALITIES:
AM I USING THE RIGHT TECHNIQUE?

DISCLOSURE/ OBJECTIVES

REFERENCES

OKLAHOMA ASSOCIATION OF NURSE ANESTHETISTS

STRATEGIES

MODES OF VENTILATION

BASICS OF MECHANICAL VENTILATION

PATHOPHYSIOLOGY REVIEW

HISTORY

RICHARD WILSON, DNAP, CRNA, FAANA
DREAMMAKER ANESTHESIA SERVICES, LLC

DISCLOSURE STATEMENT

I have no financial conflicts of interest to disclose

I will not be discussing off-label medication use

OBJECTIVES

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At the end of this presentation the learner will be able to:

1) Discuss basic physiology associated with normal lung function.

2) Discuss physiological effects of mechanical ventilation.

3) Understand the physical basis of mechanical ventilation.

4) Discuss specific settings associated with the various ventilation modes.

5) Identify the different ventilation modes best for specific settings.

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HISTORY

EARLY VENTILATION

ANESTHESIA VENTS

Existed since Biblical times

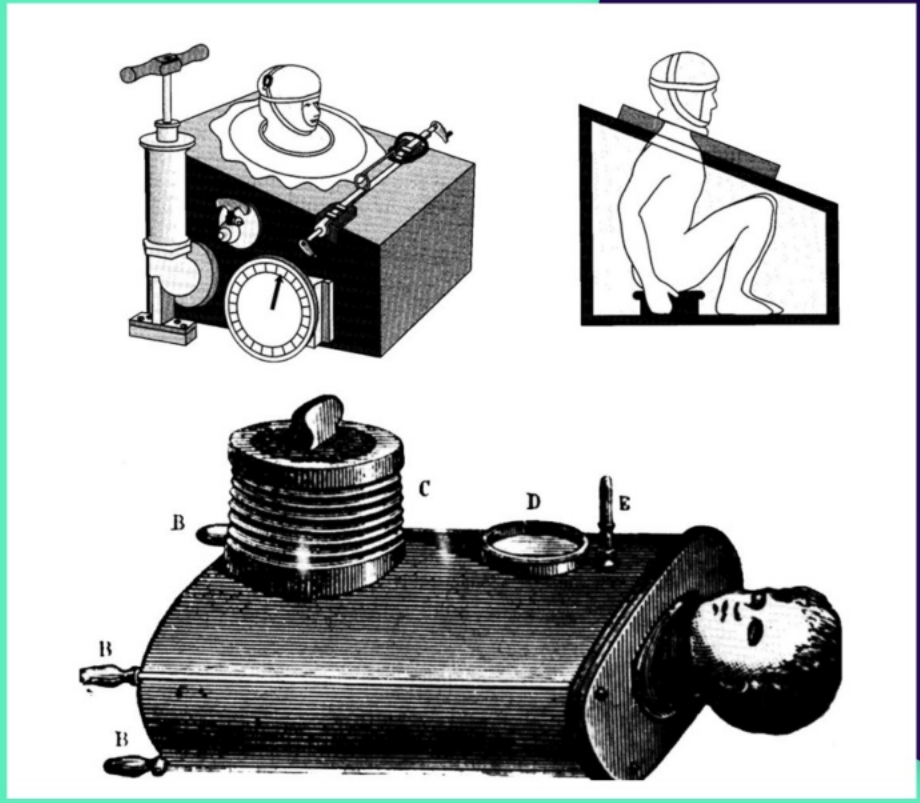
Negative pressure ventilation in 1800s

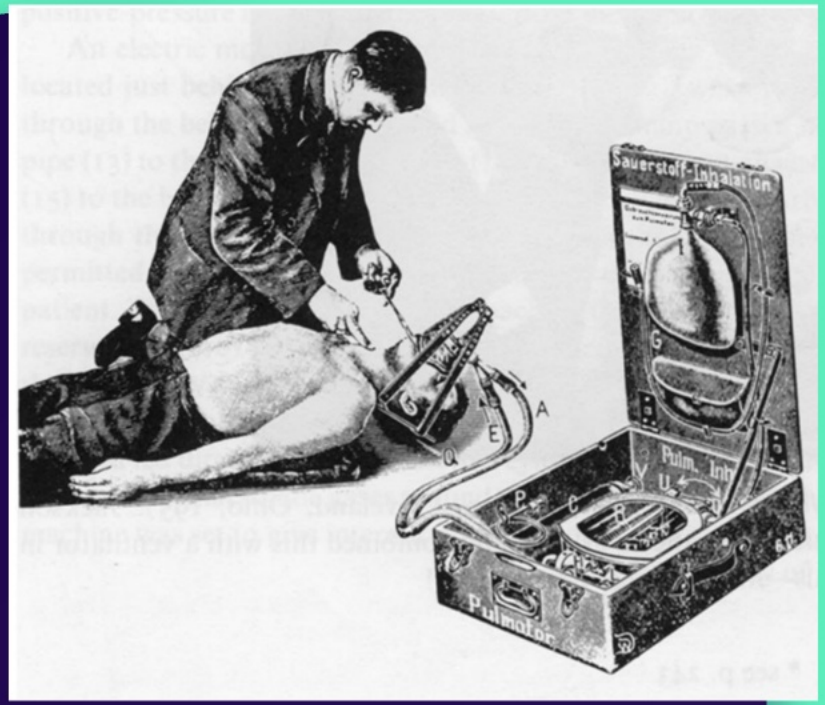
Positive pressure ventilation in 1900s

Today's ventilator in 1940s

Generation	Years	Distinguishing Factors
First	Early 1900s – Mid 1970s	Only volume-controlled ventilation
Second	Mid 1970s – Early 1980s	First appearance of patient-triggered inspiration
Third	Early 1980s – Late 1990s	Microprocessor control
Fourth	Late 1990s - Present	Plethora of ventilation modes
Future	TBD	Smart ventilation w/decision support

NEGATIVE PRESSURE VENTILATORS





POSITIVE PRESSURE VENTILATORS

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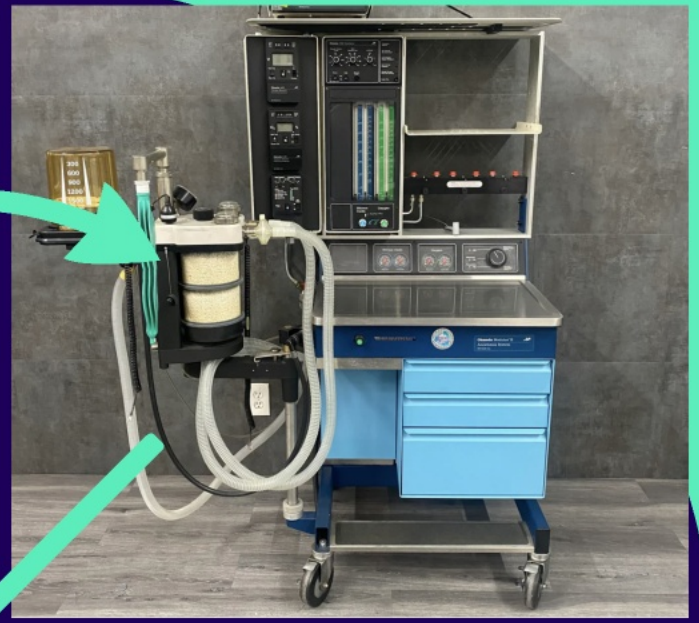

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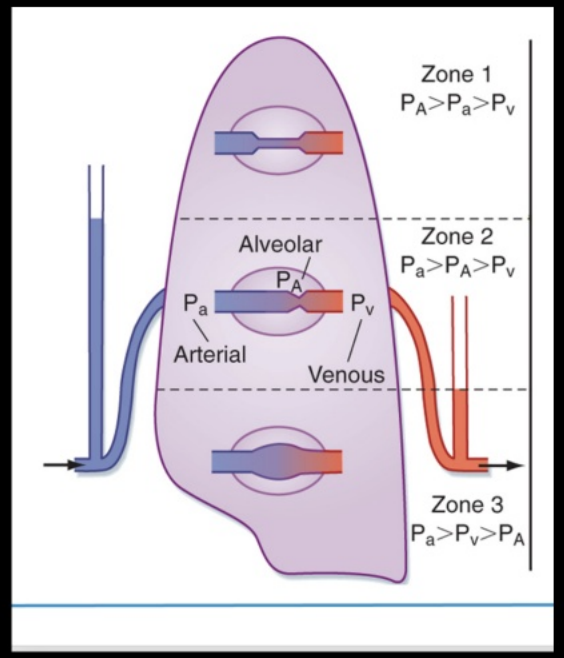
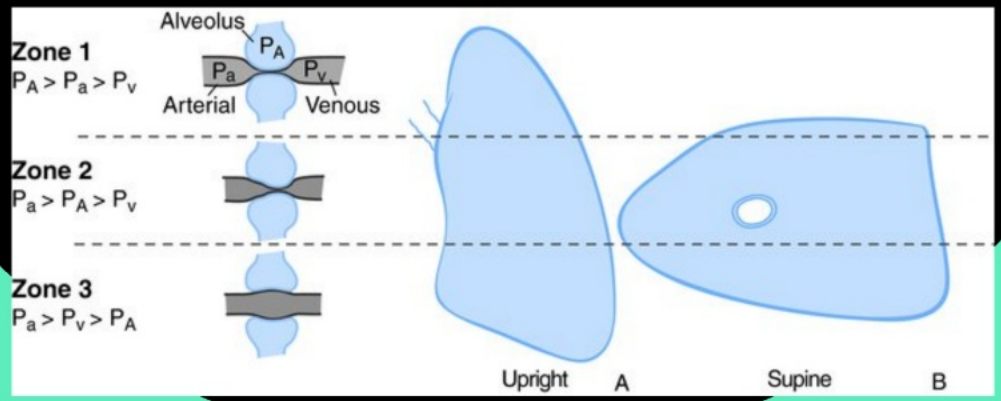
PATHOPHYSIOLOGY

GAS EXCHANGE

COMPLIANCE VS RESISTANCE

West Zones

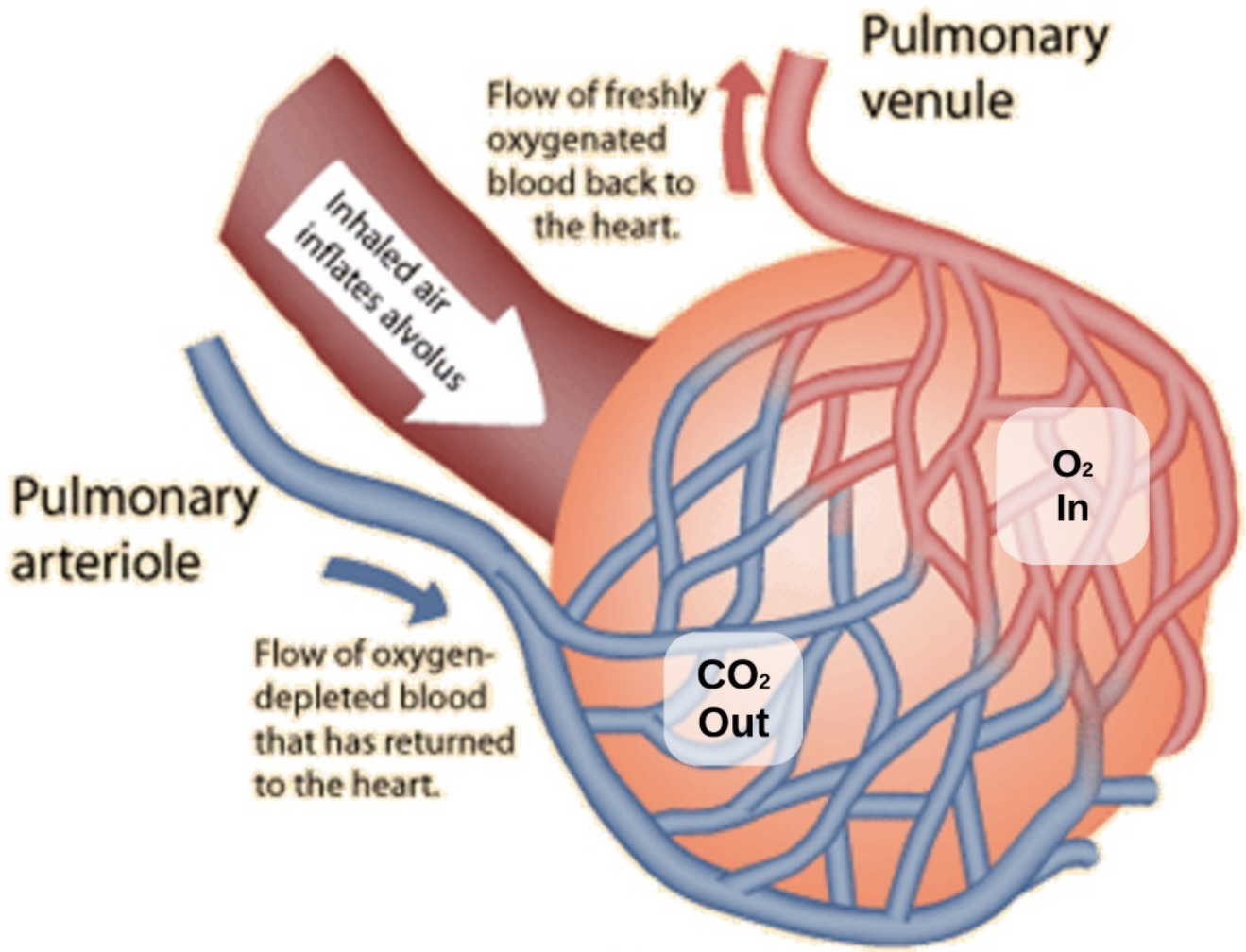




VENTILATION/ PERFUSION

GRAPHICAL MEASUREMENTS

Oxygenation *and* Ventilation



A capillary network covers the surface of the alveolus to facilitate oxygen and carbon dioxide exchange.

PATHOPHYSIOLOGY

GAS EXCHANGE

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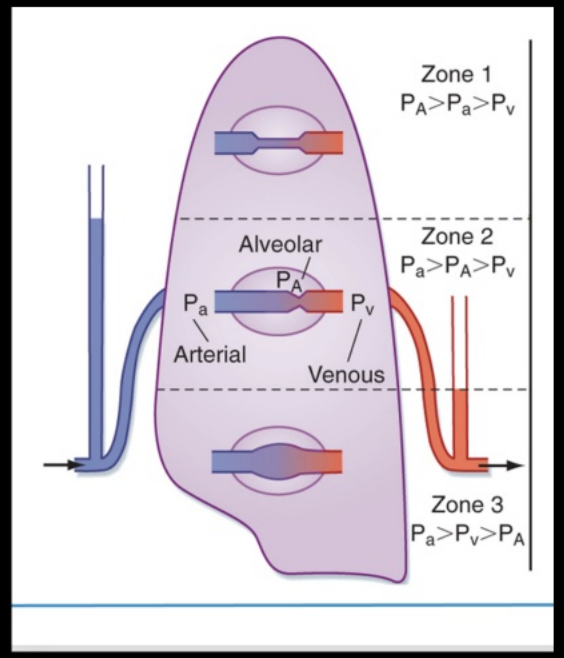
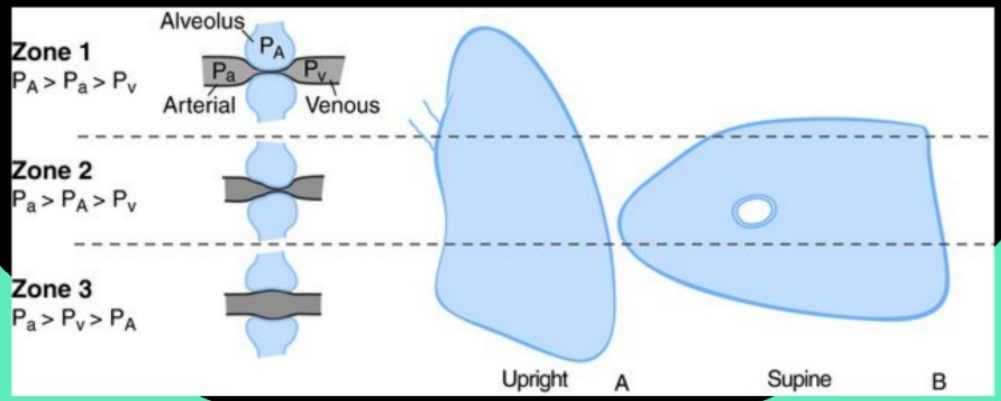
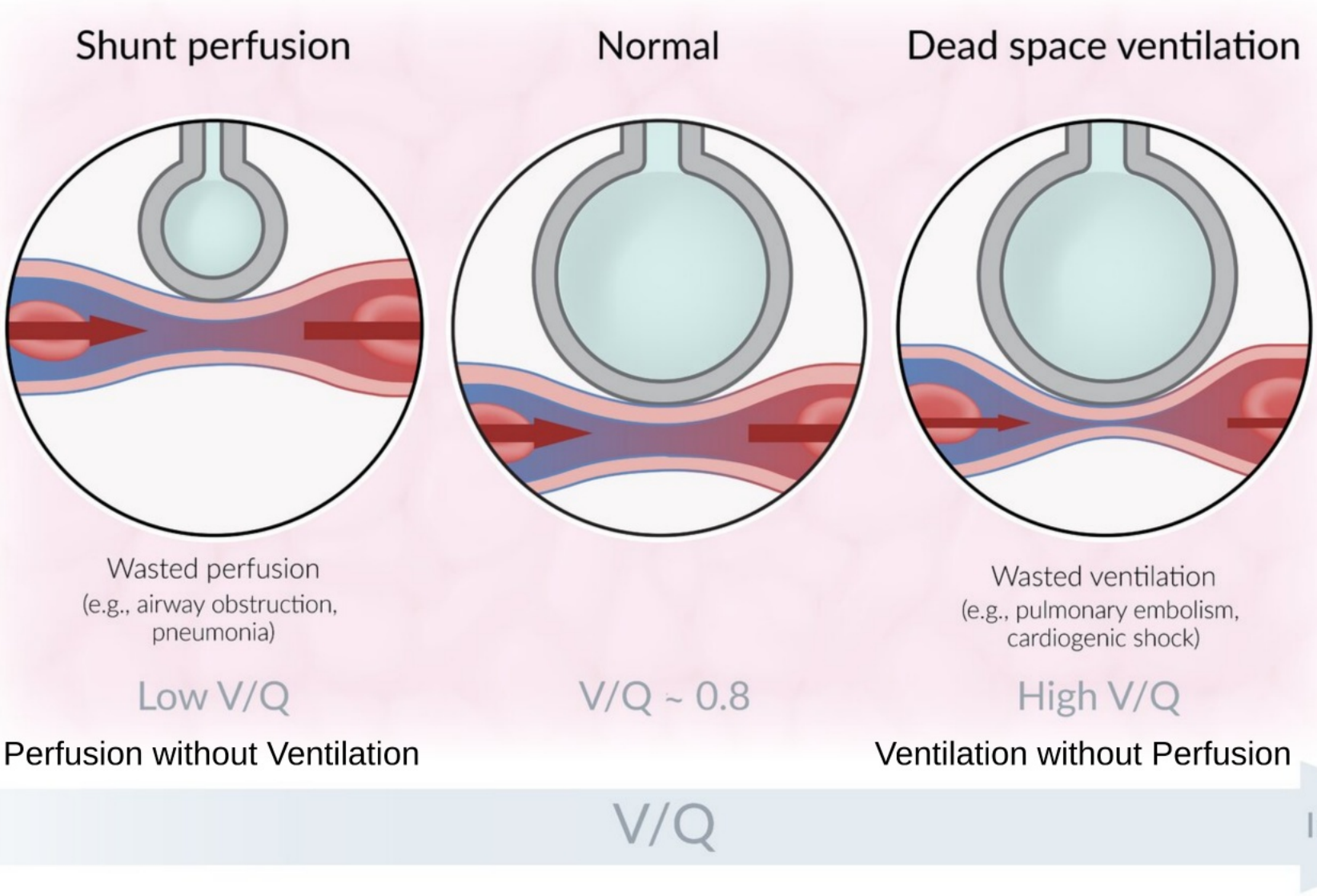




VENTILATION/ PERFUSION

GRAPHICAL MEASUREMENTS

V/Q MATCHING

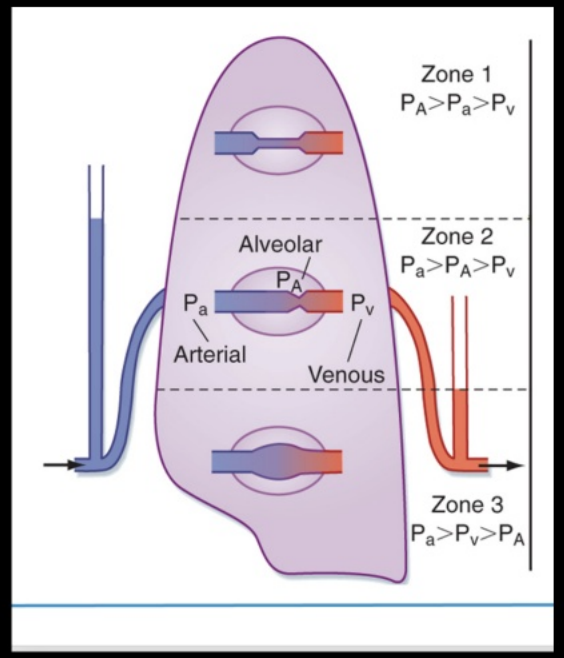

Shunt perfusion
Normal
Dead space ventilation
Wasted perfusion
(e.g., airway obstruction, pneumonia)
Wasted ventilation
(e.g., pulmonary embolism, cardiogenic shock)
Low V/Q
V/Q ~ 0.8
High V/Q
Perfusion without Ventilation
Ventilation without Perfusion
Zero
V/Q
Infinity

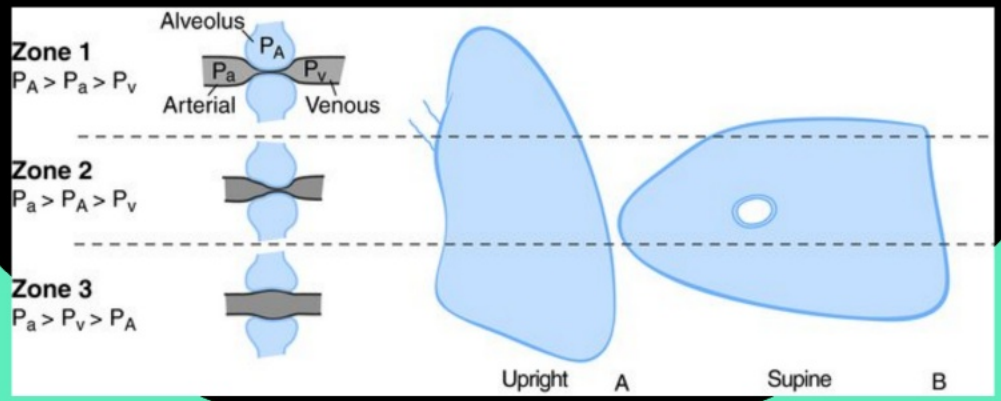
PATHOPHYSIOLOGY

GAS EXCHANGE

COMPLIANCE VS RESISTANCE

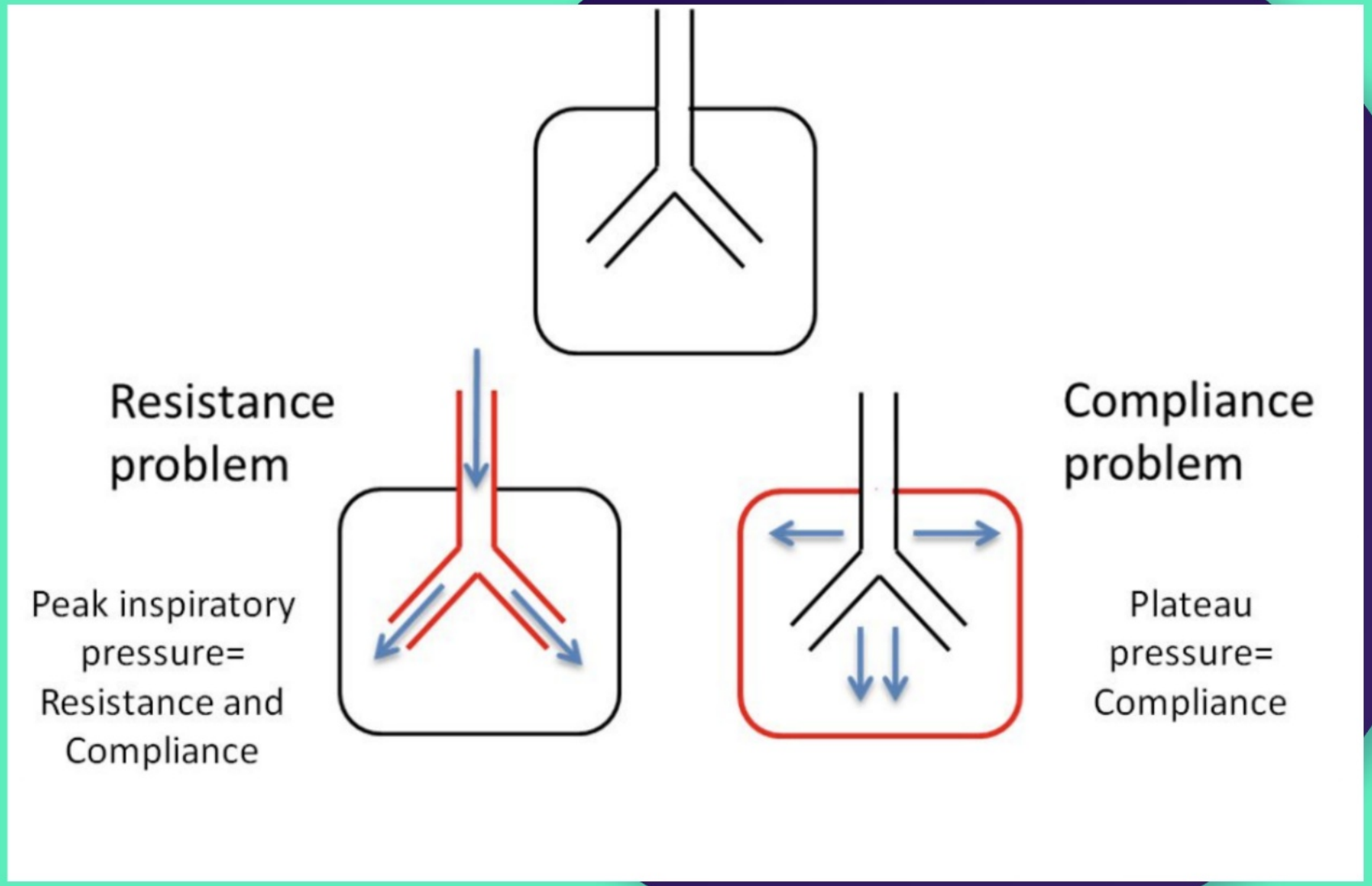
West Zones





VENTILATION/ PERFUSION

GRAPHICAL MEASUREMENTS



COMPLIANCE

Volume change per unit pressure
Lungs are very compliant

RESISTANCE

Change in transpulmonary pressure needed to produce flow of gas

PATHOPHYSIOLOGY

GAS EXCHANGE

COMPLIANCE VS RESISTANCE

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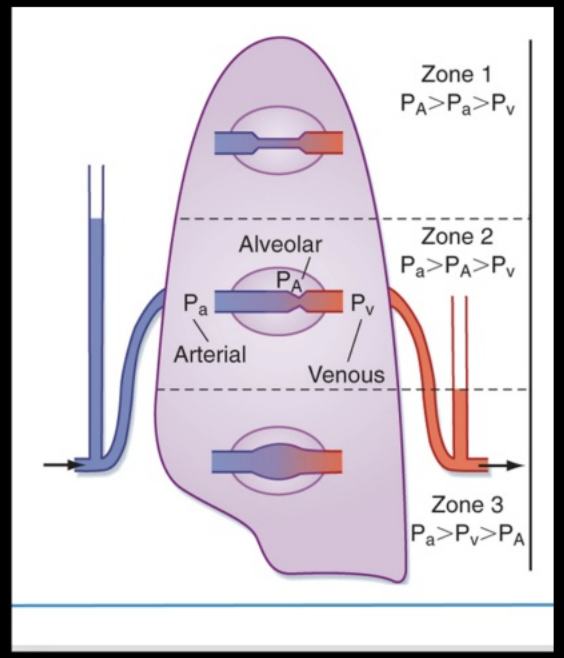
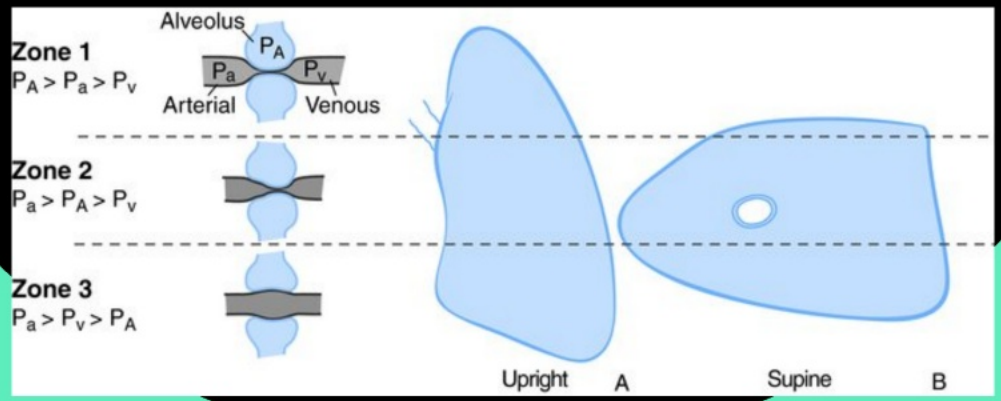
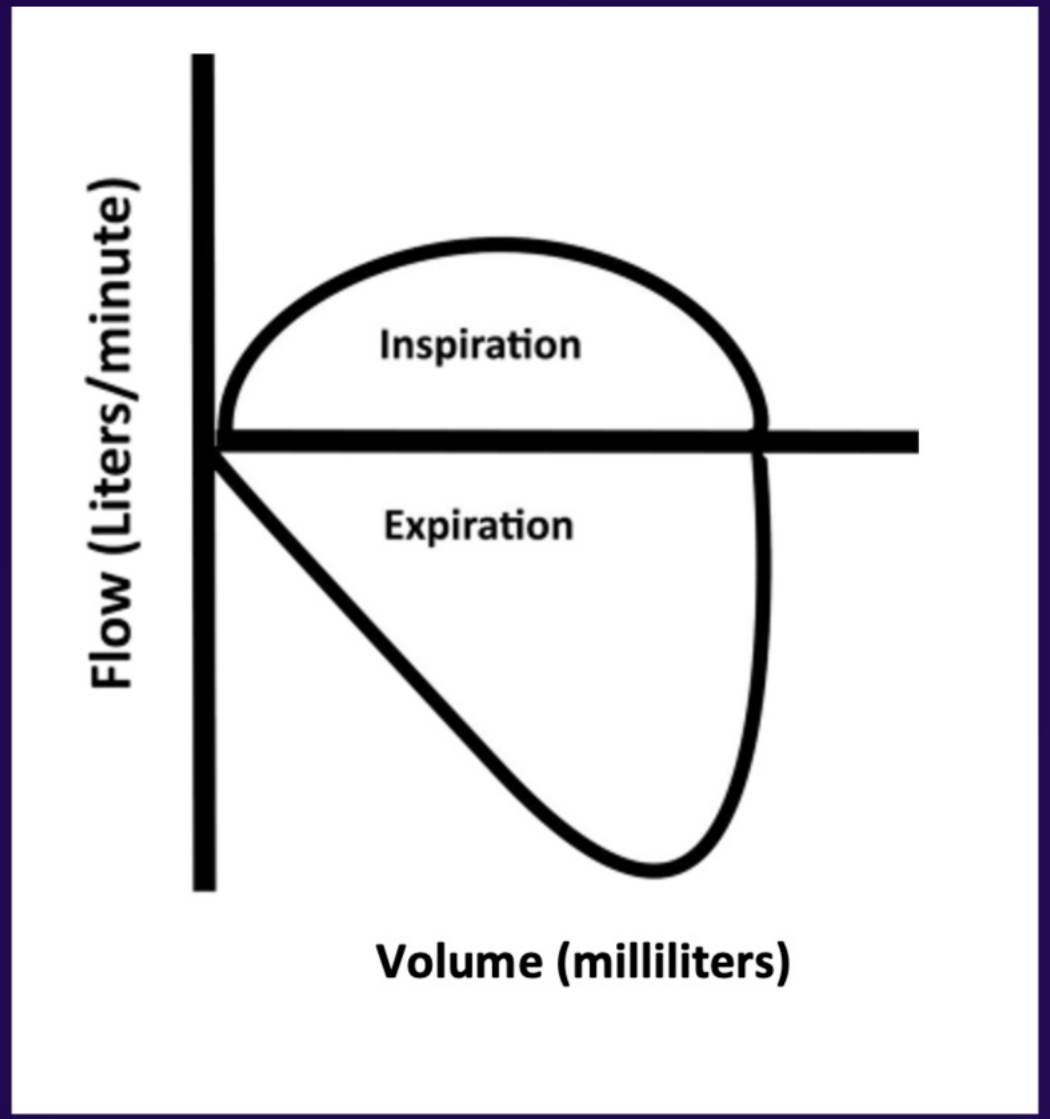
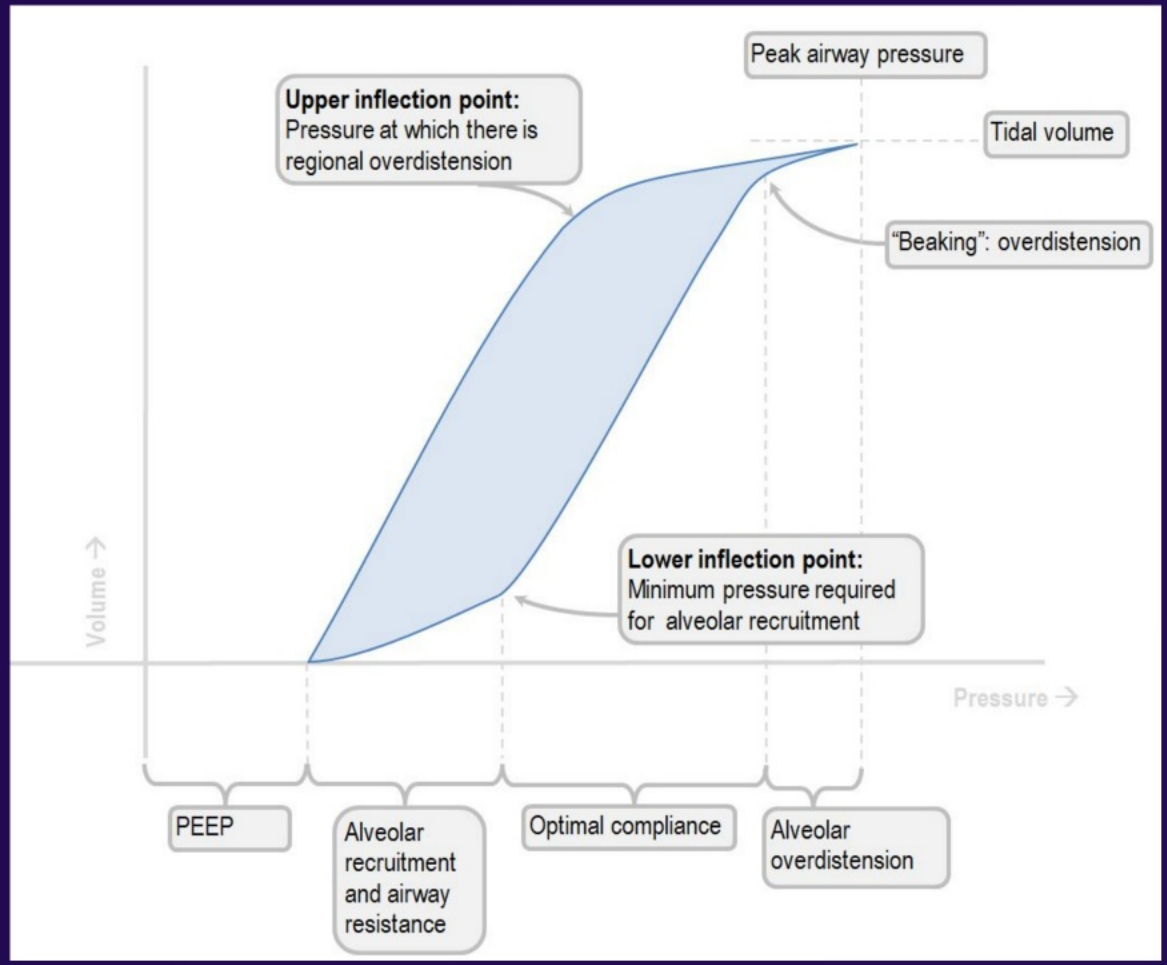




VENTILATION/ PERFUSION

GRAPHICAL MEASUREMENTS


Flow (Liters/minute)
Inspiration
Expiration
Volume (milliliters)


Peak airway pressure
Upper inflection point:
Pressure at which there is regional overdistension
Tidal volume
"Beaking": overdistension
Lower inflection point:
Minimum pressure required for alveolar recruitment
Volume →
Pressure →
PEEP
Alveolar recruitment and airway resistance
Optimal compliance
Alveolar overdistension

PATHOPHYSIOLOGY

GAS EXCHANGE

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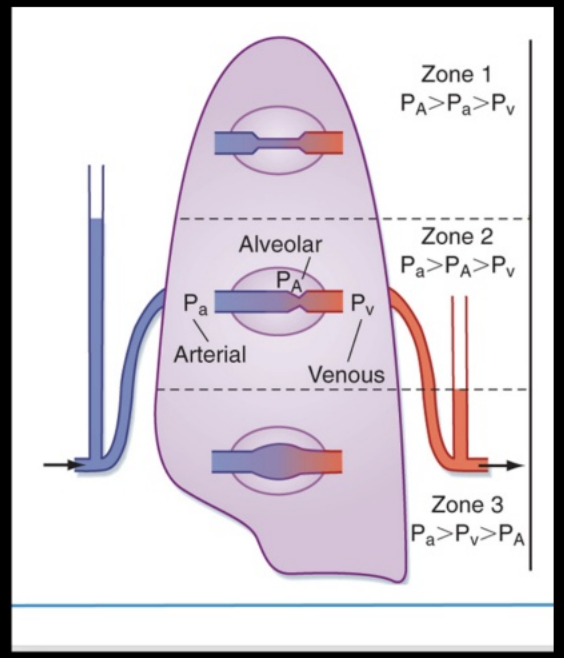

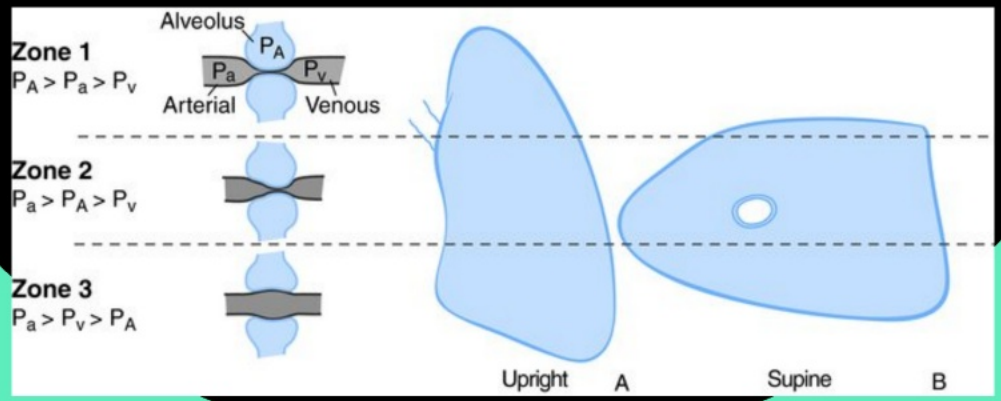

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DREAMMAKER ANESTHESIA SERVICES, LLC

ICU VS. ANESTHESIA

ICU

Ventilatory Problem
Diseased lungs
Respiratory center in brain
Airway
Usually long term problem involving weaning
Supine usually

Anesthesia

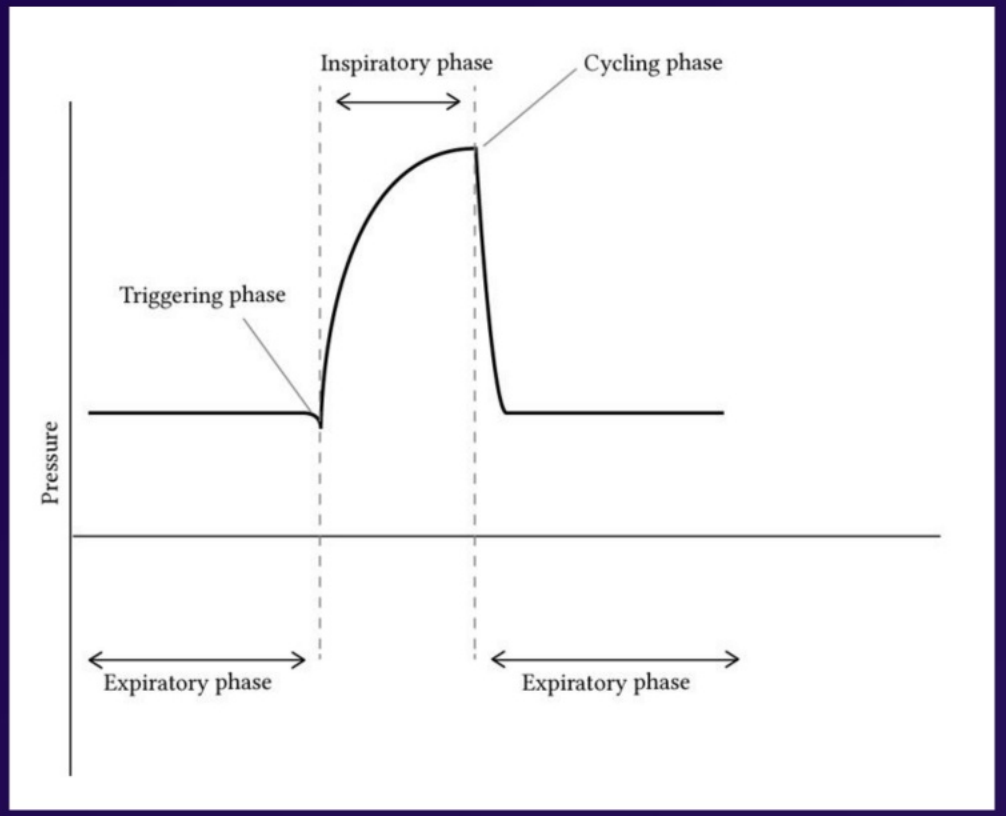
Support while under anesthesia
Healthy
Minimal comorbidities
Generally short term from our standpoint
Supine, prone, lateral, etc.

Considerations

Comorbidities
+
Anesthesia Type
+
Positioning
+
Procedure
+
Pharmacology

TERMS

VARIABLES



PHASE VARIABLE

TRIGGER VARIABLE

CYCLE VARIABLE

PHASE VARIABLES

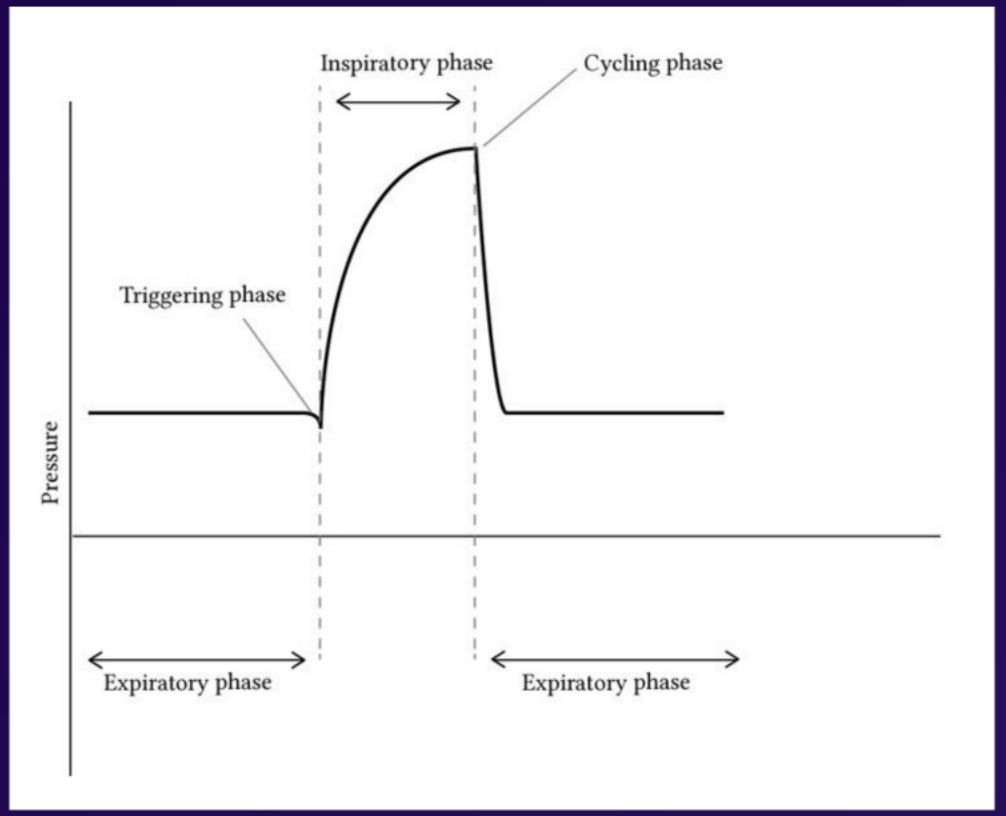
4 phases:

- Change from expiration to inspiration
- Inspiration
- Change from inspiration to expiration
- Expiration

Variables measured

Pressure
Volume
Flow
Time

VARIABLES



PHASE VARIABLE

TRIGGER VARIABLE

CYCLE VARIABLE

TRIGGER VARIABLE

(Initiates inspiration)

Time

Breath initiated according to set frequency independent of patient effort

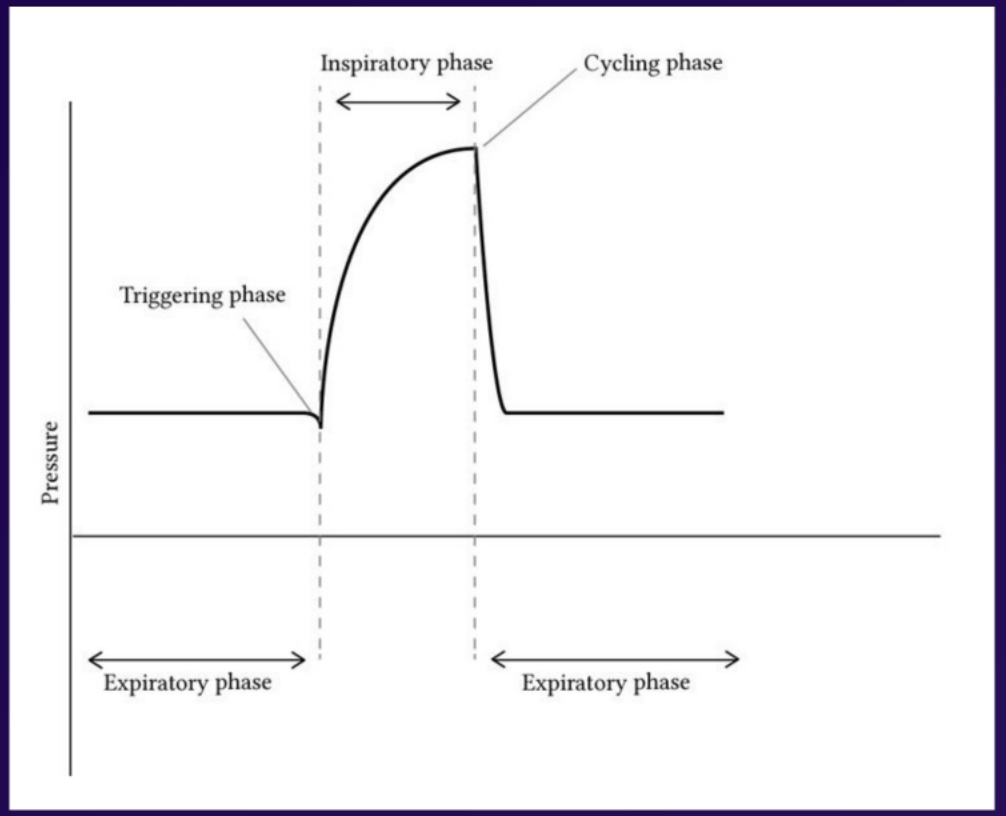
Pressure

Drop in baseline pressure sensed with patient effort and breath given independent of set frequency

Flow/Volume

Inspiratory effort sensed by flow or volume into the lungs

VARIABLES



PHASE VARIABLE

TRIGGER VARIABLE

CYCLE VARIABLE

CYCLE VARIABLE

(Used to end inspiration)

Preset value reached

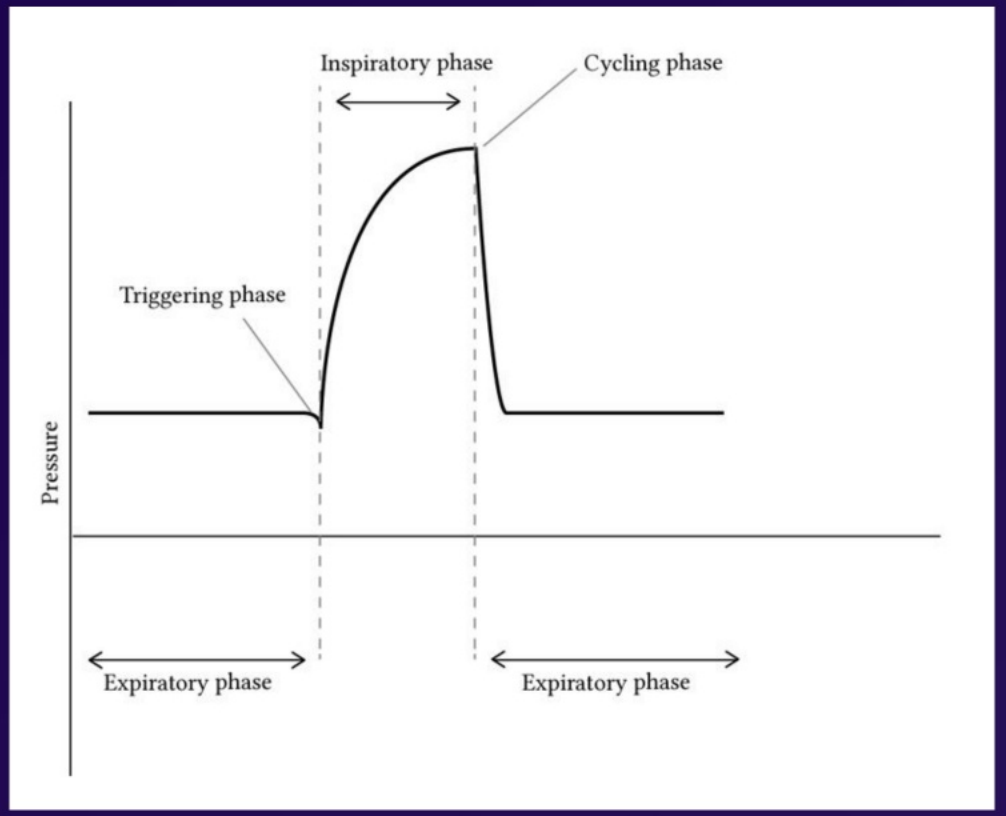
Pressure
Preset pressure is reached

Volume
Preset volume flows through ventilator valve

Flow
Delivers flow until preset level is reached (PSV)

Time
Preset inspiratory time cycle as elapsed

VARIABLES



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MECHANICAL VENTILATION

Targeted end points

Every mode is not for every patient

Understanding nuances is important

Volume, frequency and timing of gas delivered to lungs has impact on cardiovascular and respiratory systems

Mainly treating O_2 and CO_2

VCV

PCV

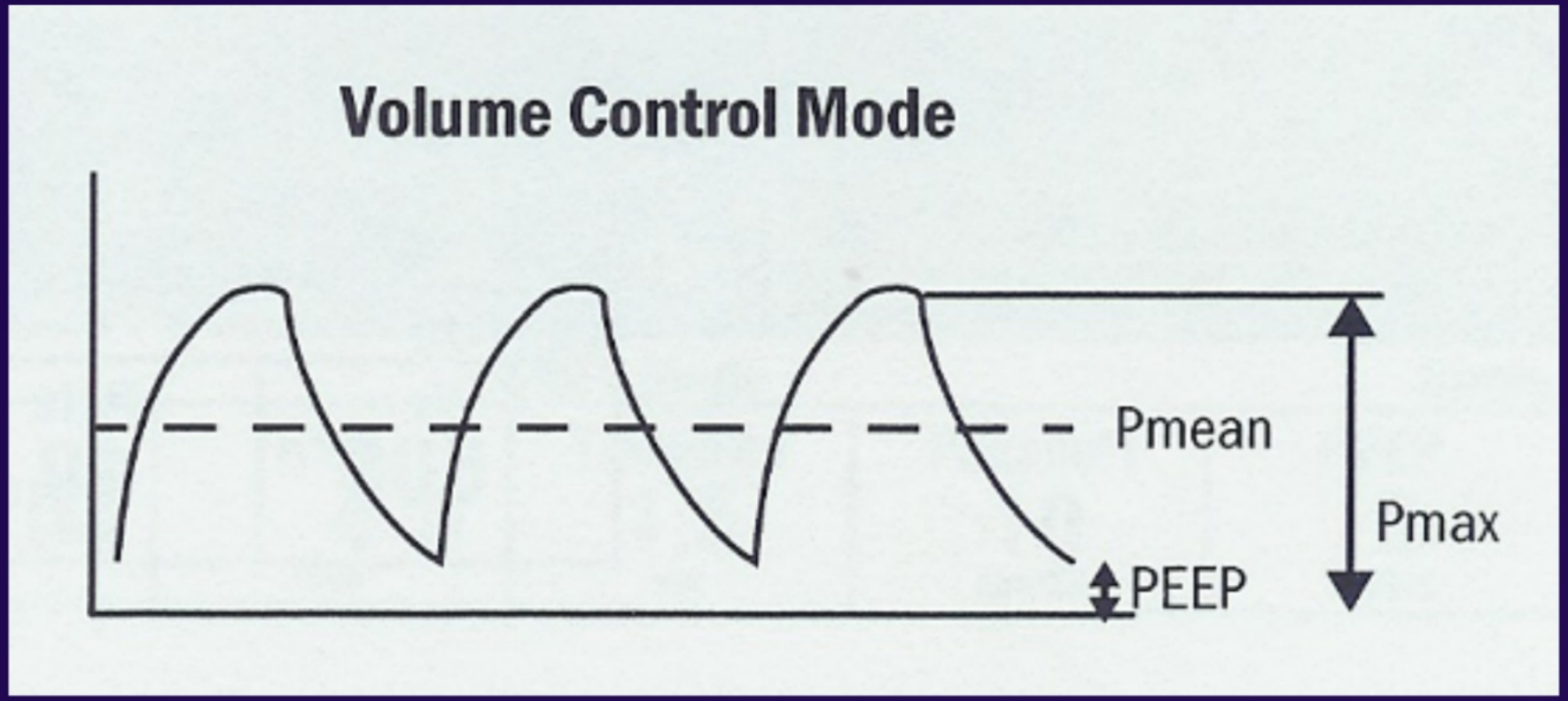
SIMV

PCVG

PSV
PRO

CPAP

VOLUME CONTROLLED VENTILATION (VCV)



Key Points

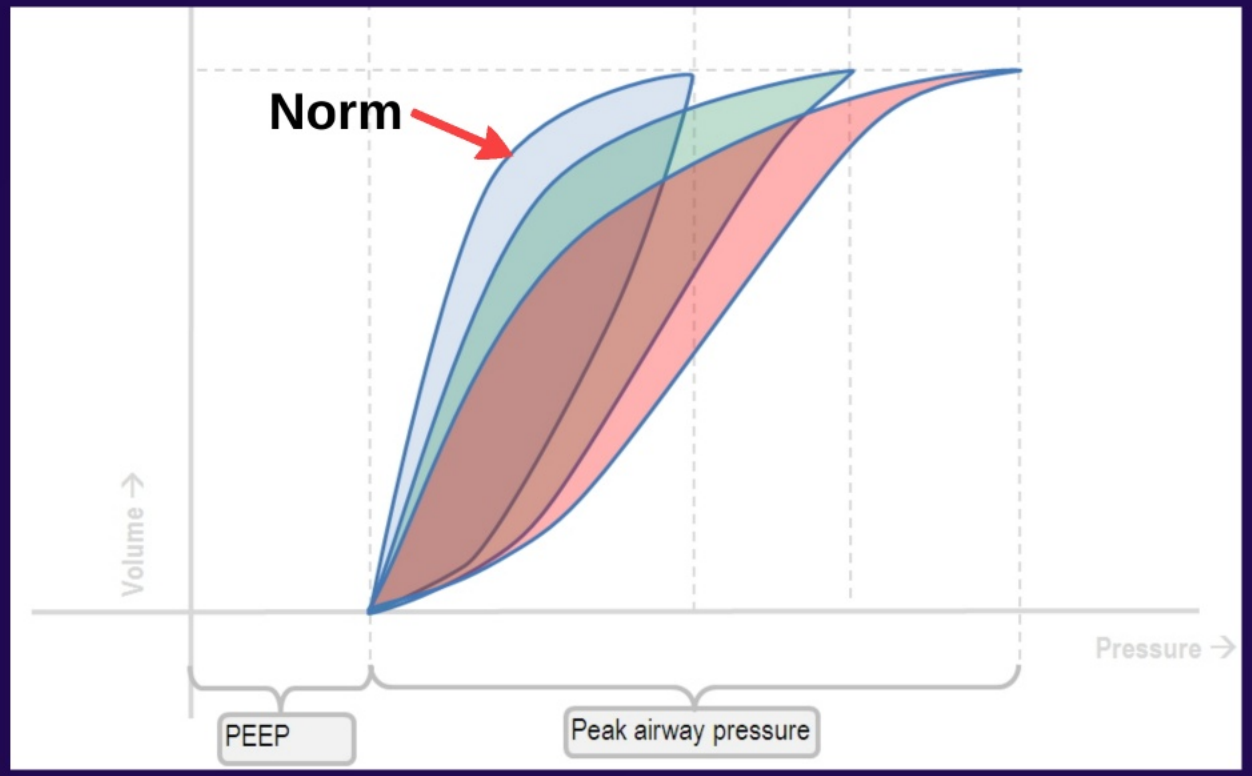
- Volume Limited
- Time Cycled
- Constant Flow

Typical Settings

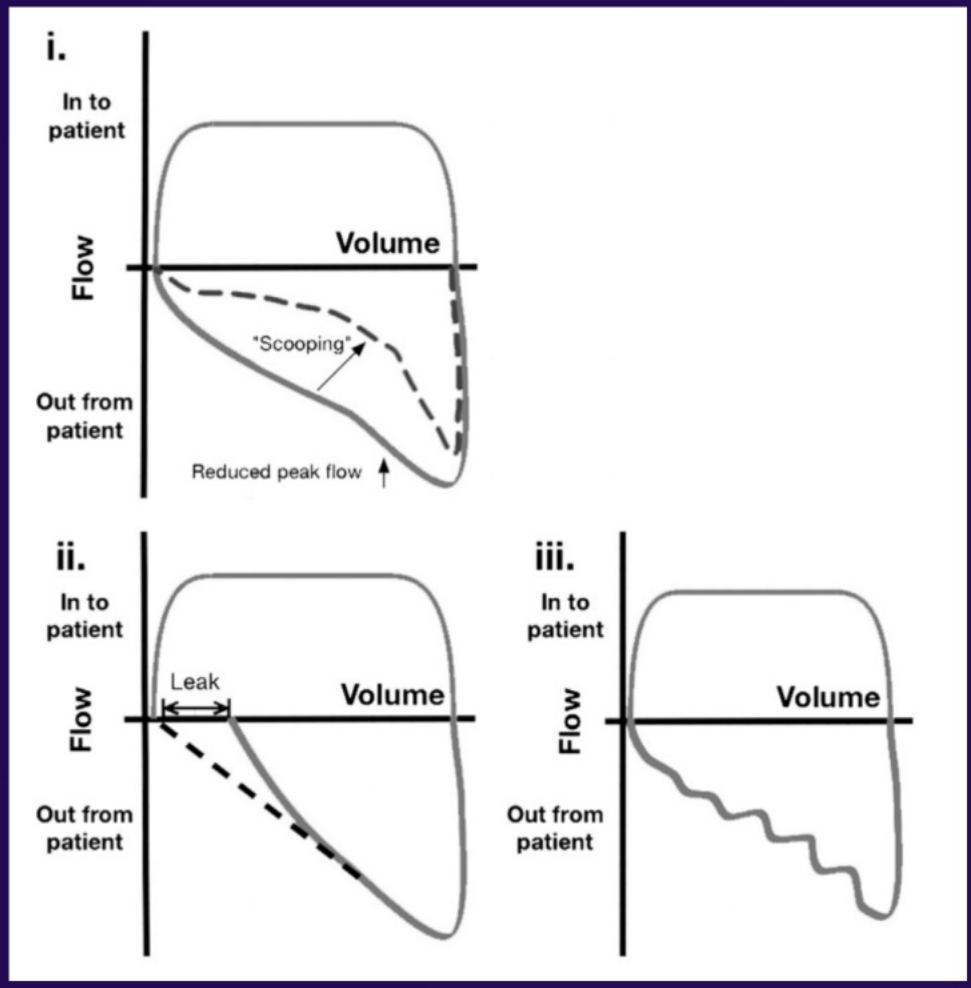
- VT = 5-8ml/kg
- RR = 6-12 bpm
- PEEP = 4cm H2O
- I:E = 1:2

VOLUME CONTROLLED VENTILATION

Decreased Compliance



Obstruction, Leak and Secretions



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PSV
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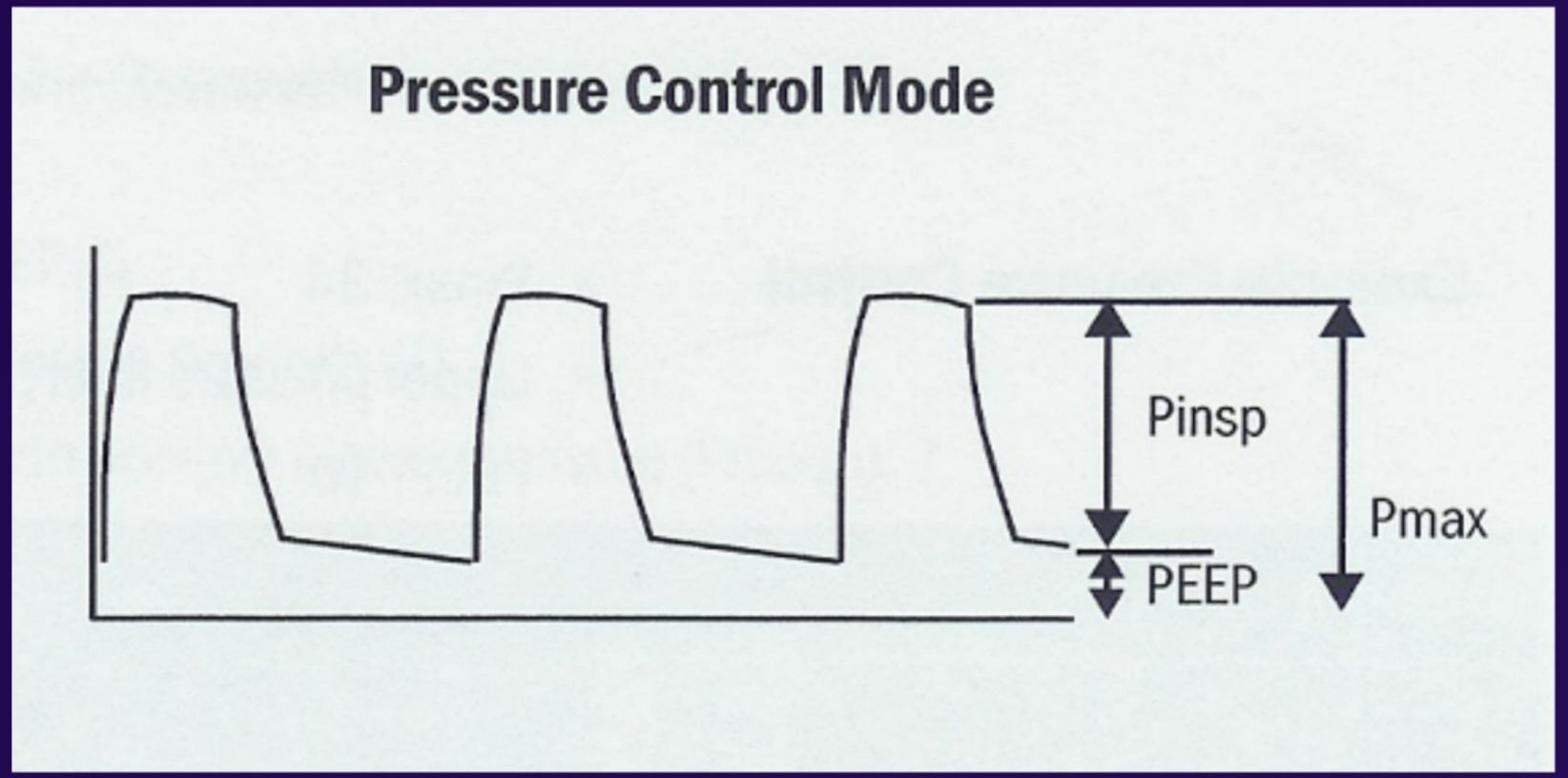
PRESSURE CONTROLLED VENTILATION (PCV)



Key Points

- Pressure Limited
- Time Cycled
- Decelerating Flow Pattern

Typical Settings

- PIP = 20cmH2O
- RR = 6-12bpm
- PEEP = 0cmH2O
- I:E = 1:2

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PCV

SIMV

PCVG

PSV
PRO

CPAP

SYNCHRONIZED INTERMITTENT MANDATORY VENTILATION (SIMV)

- Spontaneous breathing between mandatory machine cycled breaths supported
- Full to partial ventilatory support
- Mandatory breaths VCV or PCV
- Spontaneous breaths supported by pressure support (PS)
- Support can be flow triggered or pressure triggered

Trigger Window

- Amount of time during expiratory cycle that ventilator is sensitive to negative pressure generated by diaphragm

Sensitivity

- How much negative pressure patient needs to produce before a support is triggered

Settings:

- VT or PIP
- RR
- PEEP
- I:E
- Pressure Support

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PCV

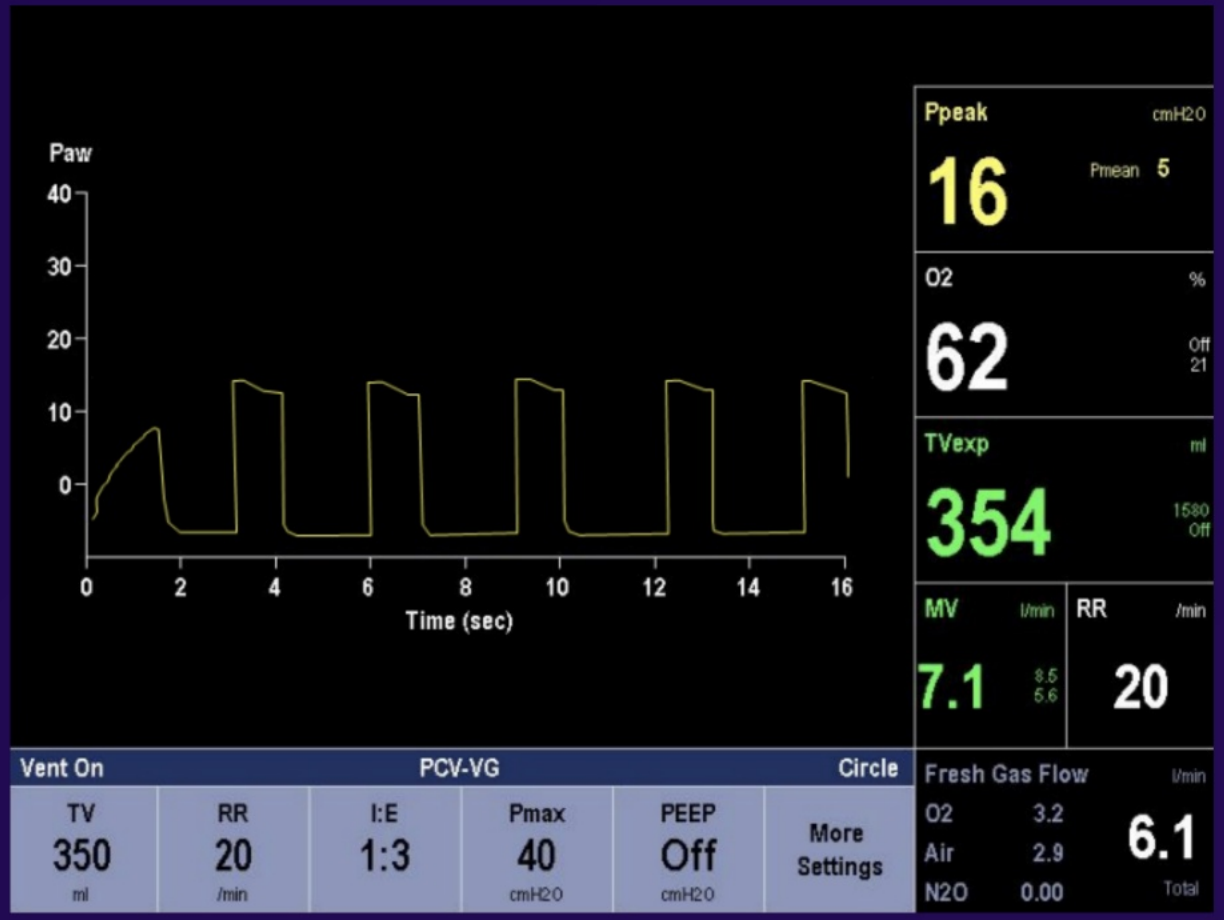
SIMV

PCVG

PSV
PRO

CPAP

PRESSURE-CONTROLLED VOLUME-GUARANTEED (PCVG)



Settings

- VT
- RR
- PEEP
- I:E

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PCV

SIMV

PCVG

PSV
PRO

CPAP

PRESSURE SUPPORT VENTILATION - PRO (PSV PRO)

- Pressure targeted ventilation
- Responsive to patient's effort
- Augment patient's spontaneous respiration
- Backup mode for apnea
- Method for weaning, preventing atelectasis, or use with LMA

Settings

- Pressure Support
- Trigger Window
- Sensitivity
- Respiratory Rate
- Inspiratory pressure

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PCV

SIMV

PCVG

PSV
PRO

CPAP

CONTINUOUS POSITIVE AIRWAY PRESSURE (CPAP)

- Noninvasive ventilation
- Helps maintain patent airway
-
- Active in both inspiratory ***AND*** expiratory phase
- Improves oxygenation ***AND*** ventilation
- Gold standard treatment for OSA
- Avoids complications associated with intubation and PPV
- Help avoid loss of FRC before extubation

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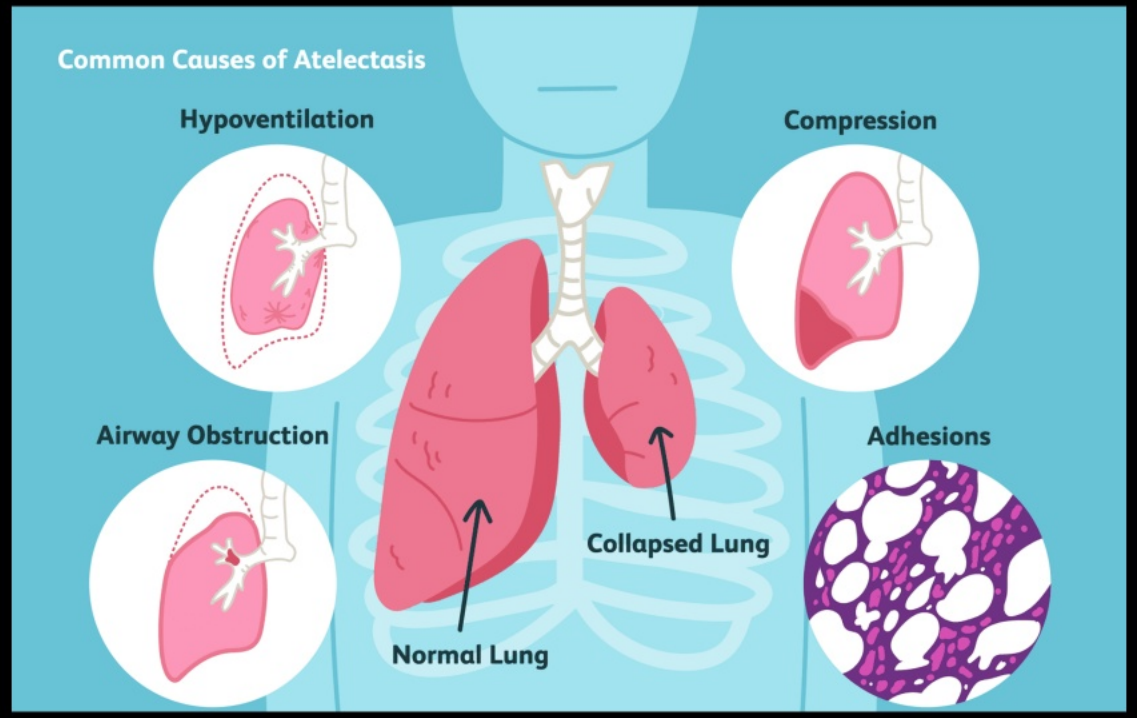
ATELECTASIS

PEEP

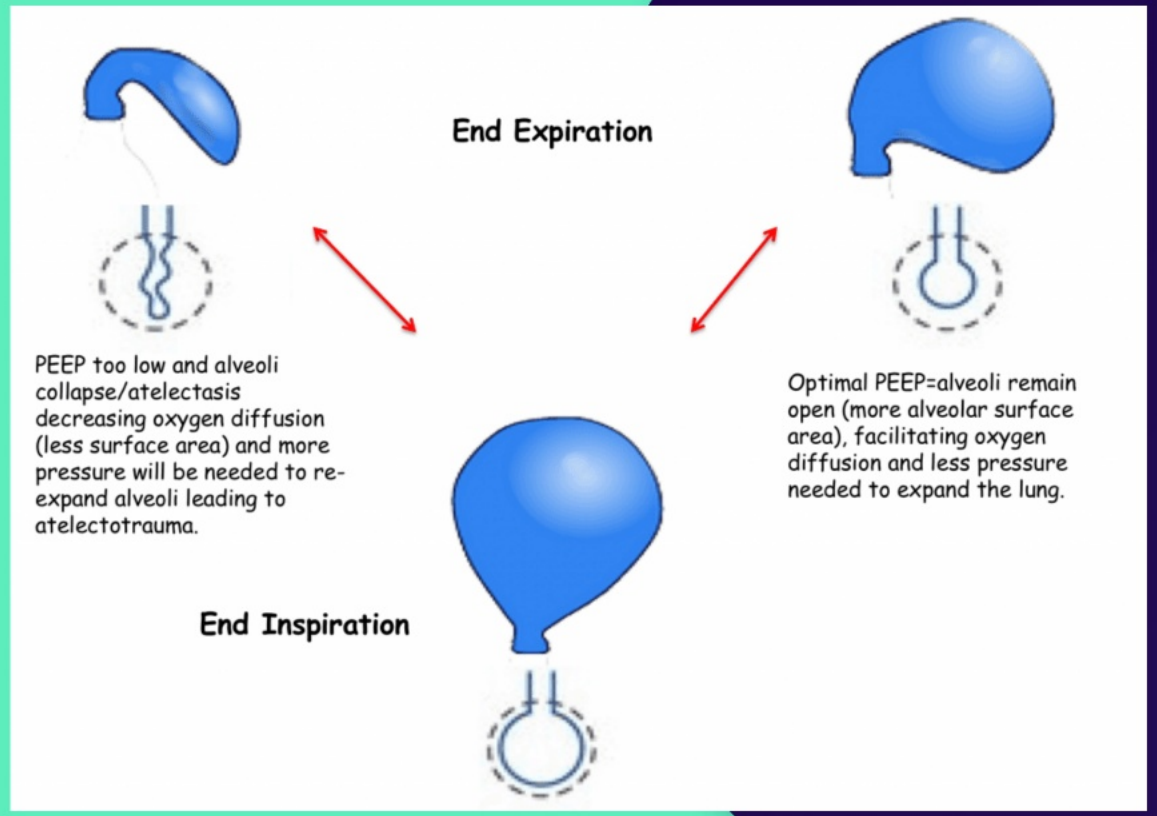
O_2 CONCENTRATION

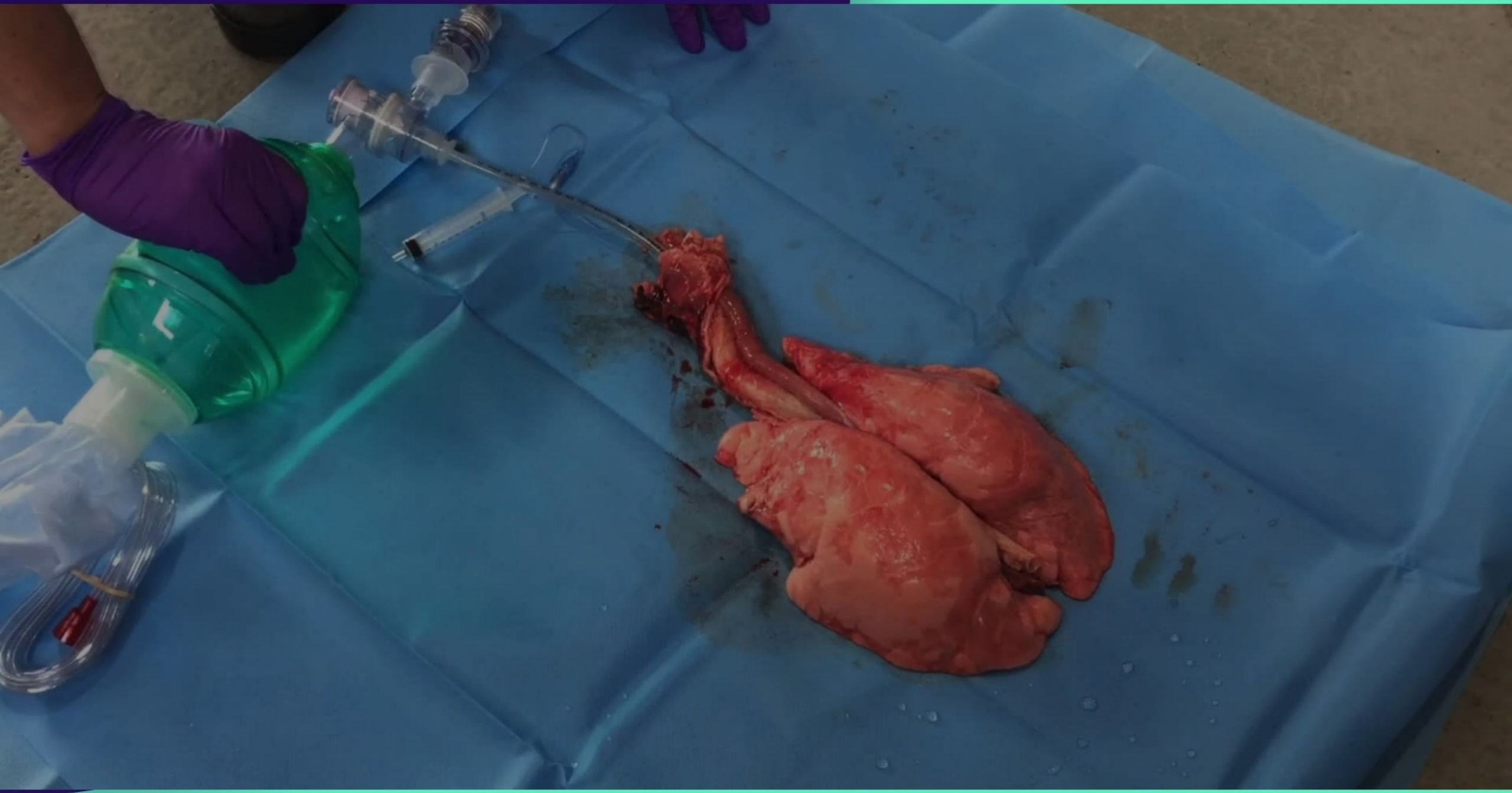


SIGH

I:E RATIO

PEEP

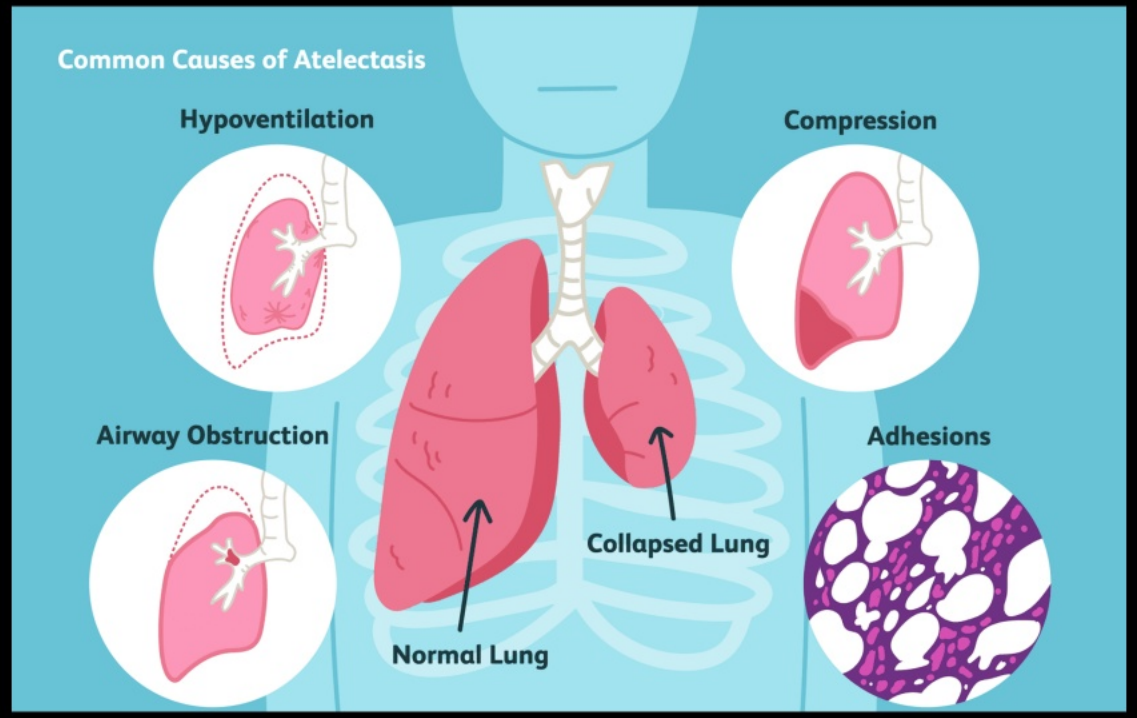

End Expiration
PEEP too low and alveoli collapse/atelectasis decreasing oxygen diffusion (less surface area) and more pressure will be needed to re-expand alveoli leading to atelectotrauma.
Optimal PEEP=alveoli remain open (more alveolar surface area), facilitating oxygen diffusion and less pressure needed to expand the lung.
End Inspiration



ATELECTASIS

PEEP

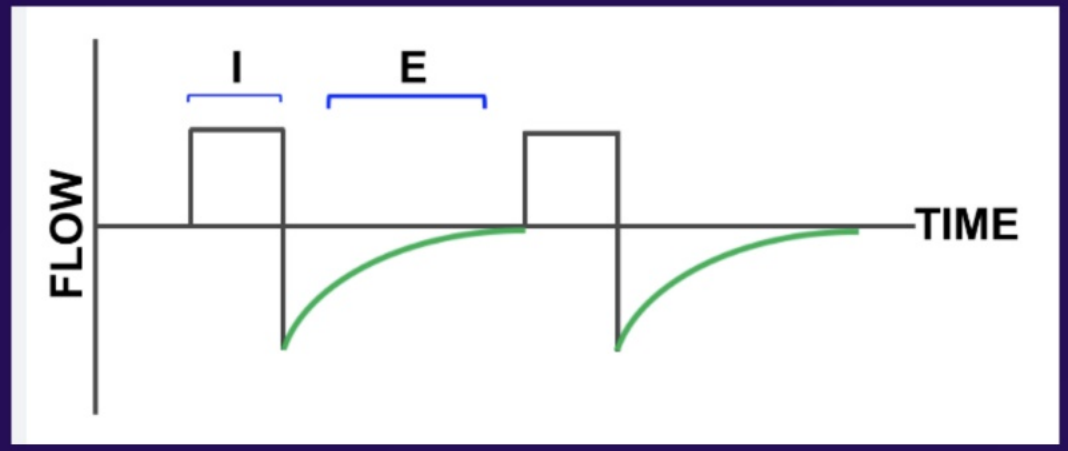
O_2 CONCENTRATION



SIGH

I:E RATIO

I:E RATIO



Normal I:E is 1:2

Higher I:E ratios good for beneficial in conditions where it is difficult for air to leave the lungs (*i.e. asthma, COPD*)

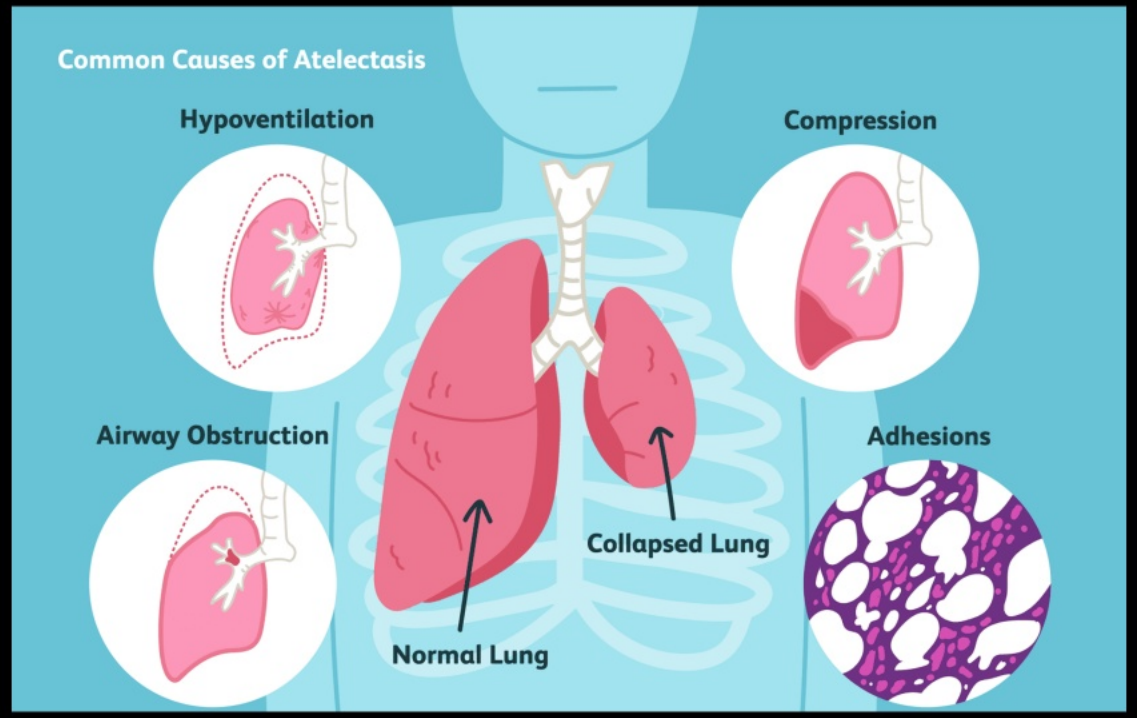
Shorter I:E ratios used with patients difficult to ventilate (*monitor for gas trapping*)

Inverse I:E ratio increases mean airway pressures and can improve oxygenation, gas exchange, and arterial oxygenation (*increased intrathoracic pressure and decreased cardiac output*)

ATELECTASIS

PEEP

O_2 CONCENTRATION



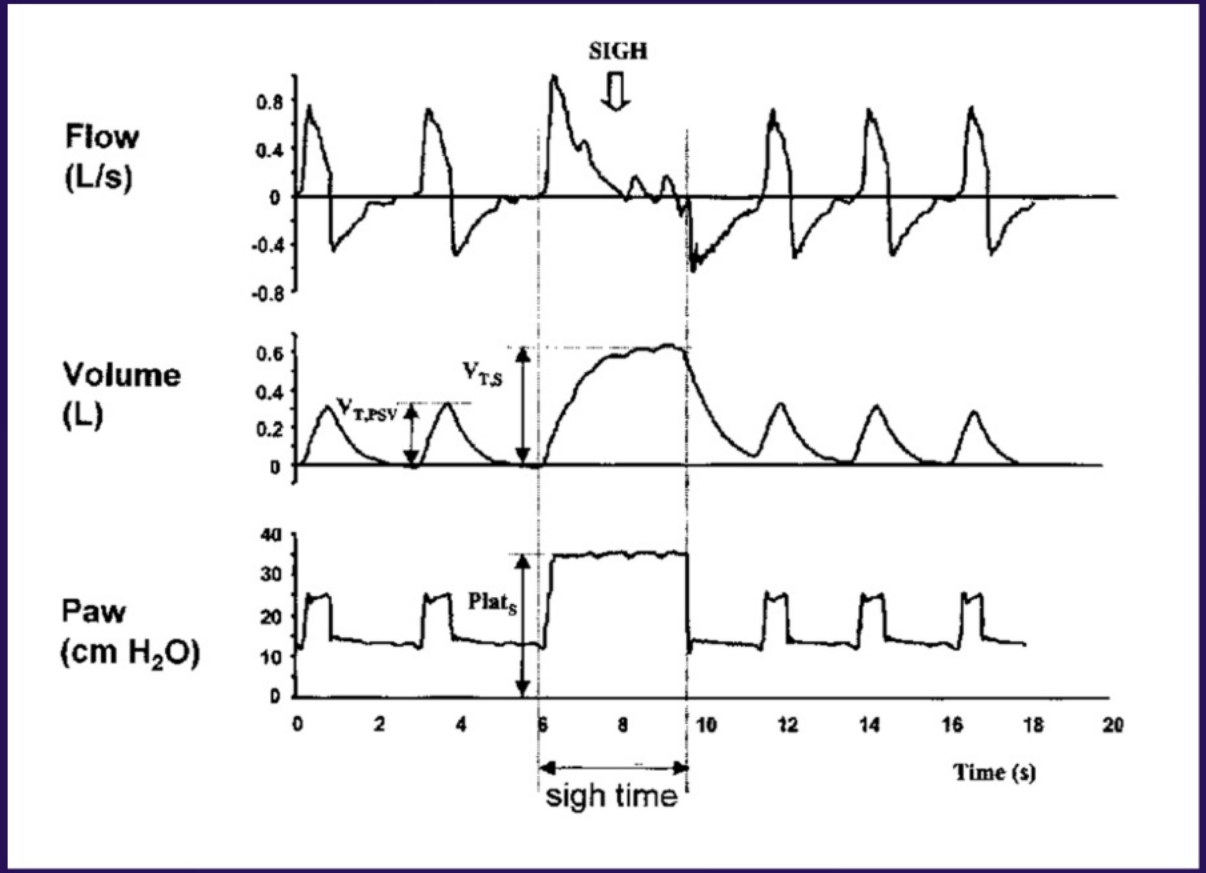
SIGH

I:E RATIO

SIGH BREATH

- Maximum expansion of lungs
- Improve gas exchange
- In ARDS, cycling of sigh breaths improved lung function
- The end-expiratory pressure PEEP increases by the set value of the intermittent PEEP

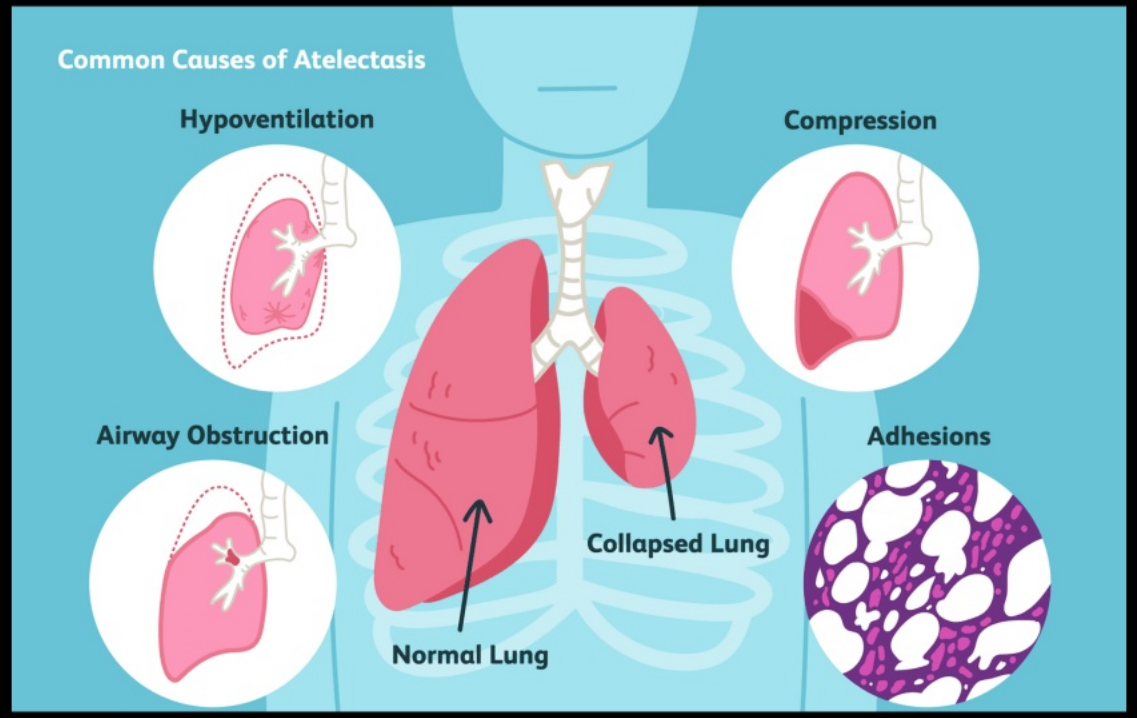
- ***Benefits***
  - improved lung elastance
  - increased release of surfactant
  - decreased effort (protective for diaphragm)



ATELECTASIS

PEEP

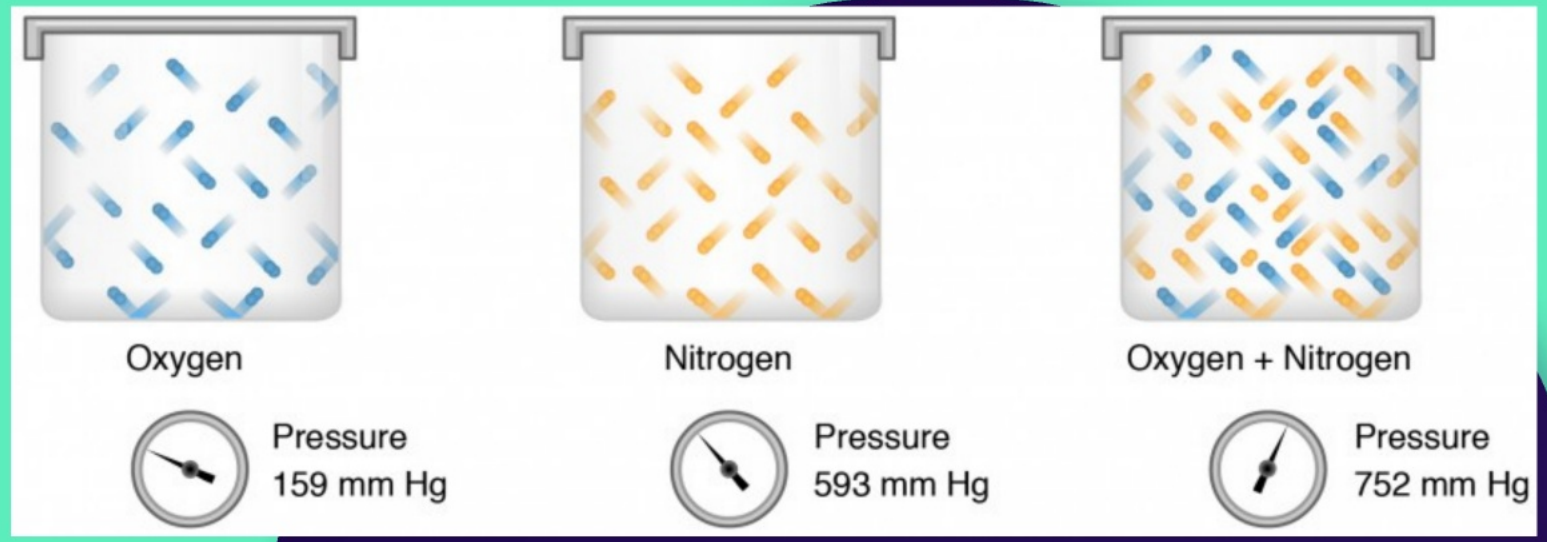
O_2 CONCENTRATION

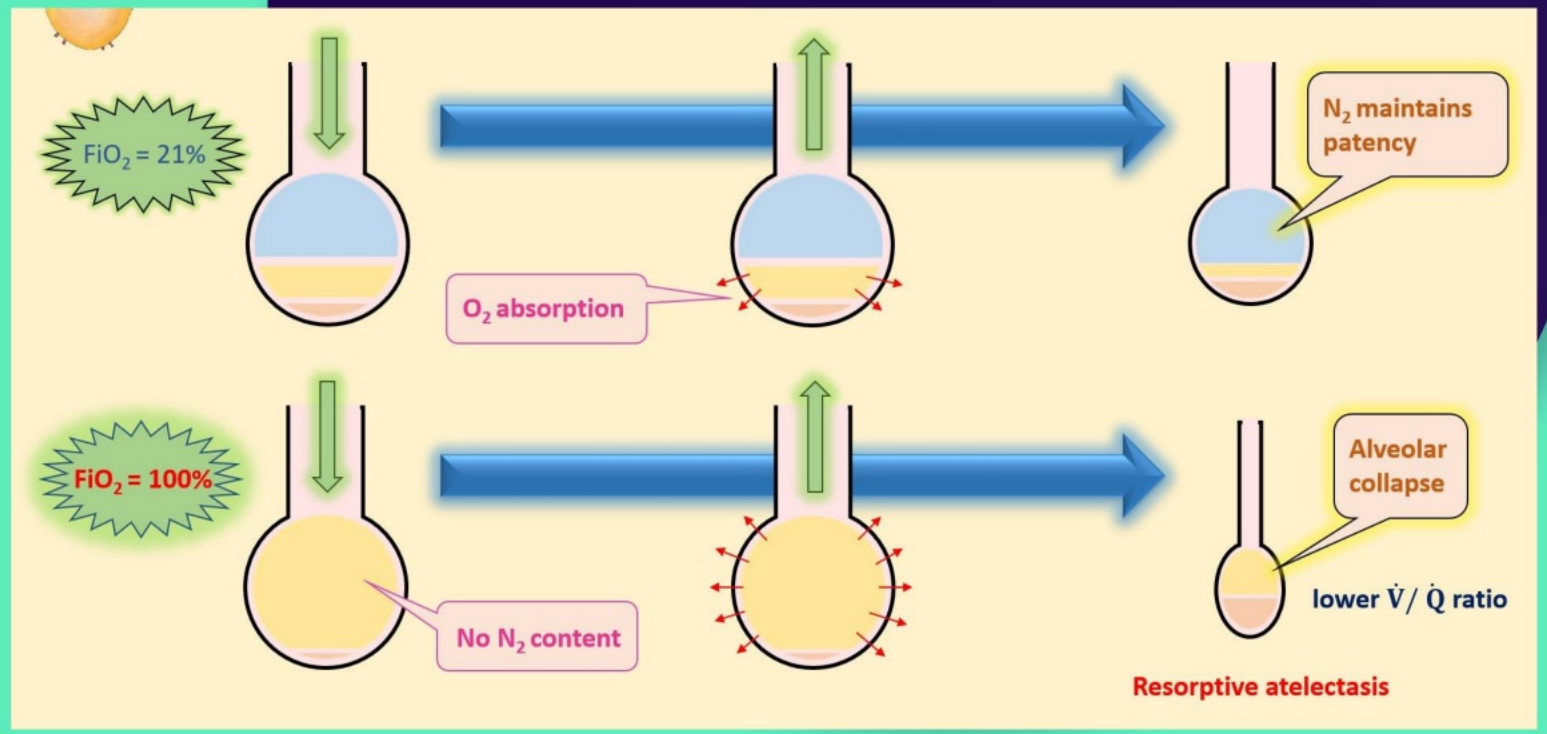


SIGH

I:E RATIO

FIO_2





Data

Atelectasis
FiO_2 1.0 = 5 min
FiO_2 0.4 = 40 min

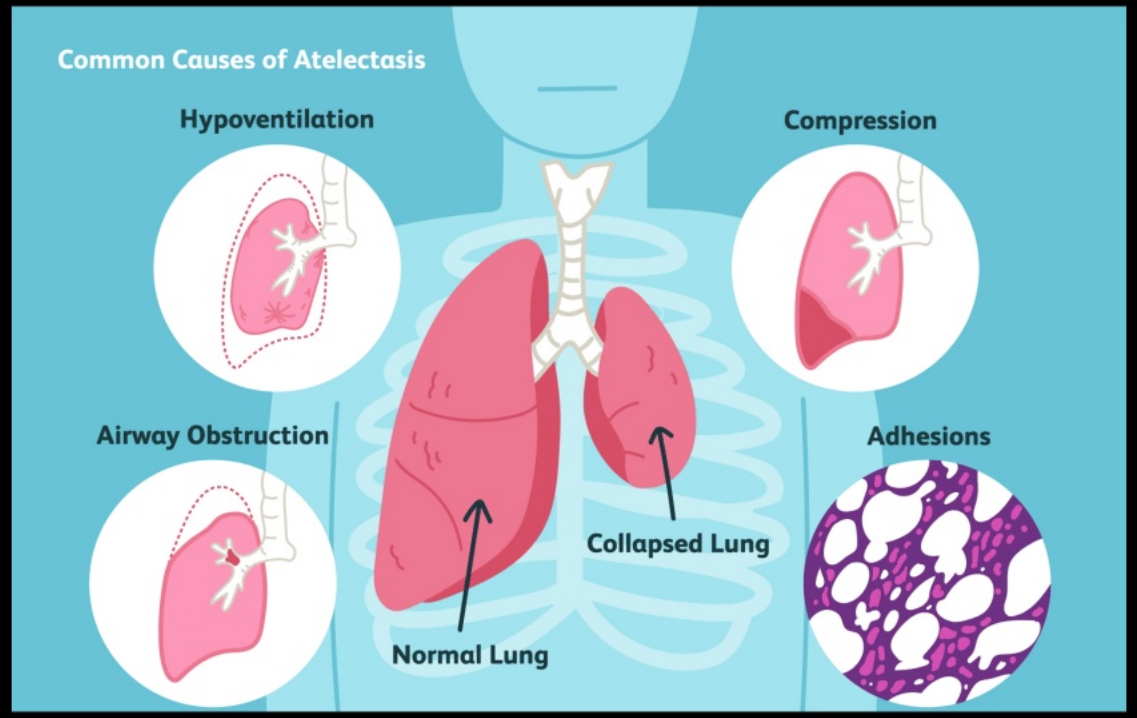
Shunt
FiO_2 1.0 = 6.5%
FiO_2 0.3 = 2.1%

Proxygenate
FiO_2 0.8 = 0.58% atelectasis
FiO_2 1.0 = 6.8% atelectasis

ATELECTASIS

PEEP

O_2 CONCENTRATION



SIGH

I:E RATIO

VENTILATION MODALITIES:
AM I USING THE RIGHT TECHNIQUE?

DISCLOSURE/ OBJECTIVES

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PATHOPHYSIOLOGY REVIEW

HISTORY

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REFERENCES

Barash, P. G., Cullen, B. F., Stoelting, R. K., Cahalan, M., & Stock, M. C. (2017). *Clinical Anesthesia* (8th ed.). Philadelphia, PA: Lippincott Williams & Wilkins. (In USC SOM Medical Library Online Resources)

Naglehout, John, Elisha, Sass, & Heiner, Jeremy (2022). *Nurse Anesthesia*, 7th ed. Elsevier Saunders, 2022.

Tobin, Martin J. (2013). Principles and Practice of Mechanical Ventilation, 3rd ed. McGraw Hill Medical.

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