DISCLOSURE/ OBJECTIVES

REFERENCES

VENTILATION MODALITIES: THERE ARE SO MANY TO USE!

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

HISTORY

PATHOPHYSIOLOGY REVIEW

BASICS OF MECHANICAL VENTILATION

MODES OF VENTILATION

STRATEGIES

DISCLOSURE STATEMENT

I have no financial conflicts of interest to disclose

I will not be discussing off-label medication use

OBJECTIVES

OBJECTIVES

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.

DISCLOSURE STATEMENT

I have no financial conflicts of interest to disclose

I will not be discussing off-label medication use

OBJECTIVES

DISCLOSURE/ OBJECTIVES

REFERENCES

VENTILATION MODALITIES: THERE ARE SO MANY TO USE!

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

HISTORY

PATHOPHYSIOLOGY REVIEW

BASICS OF MECHANICAL VENTILATION

MODES OF VENTILATION

STRATEGIES

HISTORY

Existed since Biblical times

Negative pressure ventilation in 1800s

Positive pressure ventilation in 1900s

Today's ventilator in 1940s

ANESTHESIA VENTS

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

HISTORY

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

DISCLOSURE/ OBJECTIVES

REFERENCES

VENTILATION MODALITIES: THERE ARE SO MANY TO USE!

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

HISTORY

PATHOPHYSIOLOGY REVIEW

BASICS OF MECHANICAL VENTILATION

MODES OF VENTILATION

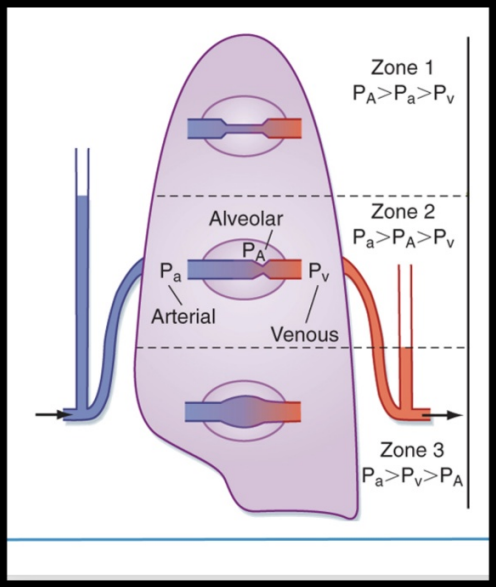
STRATEGIES

NEW JERSEY ASSOCIATION OF NURSE ANESTHETISTS est. 1939 NJANA

GAS EXCHANGE

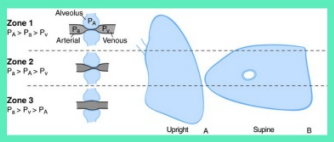
PATHOPHYSIOLOGY

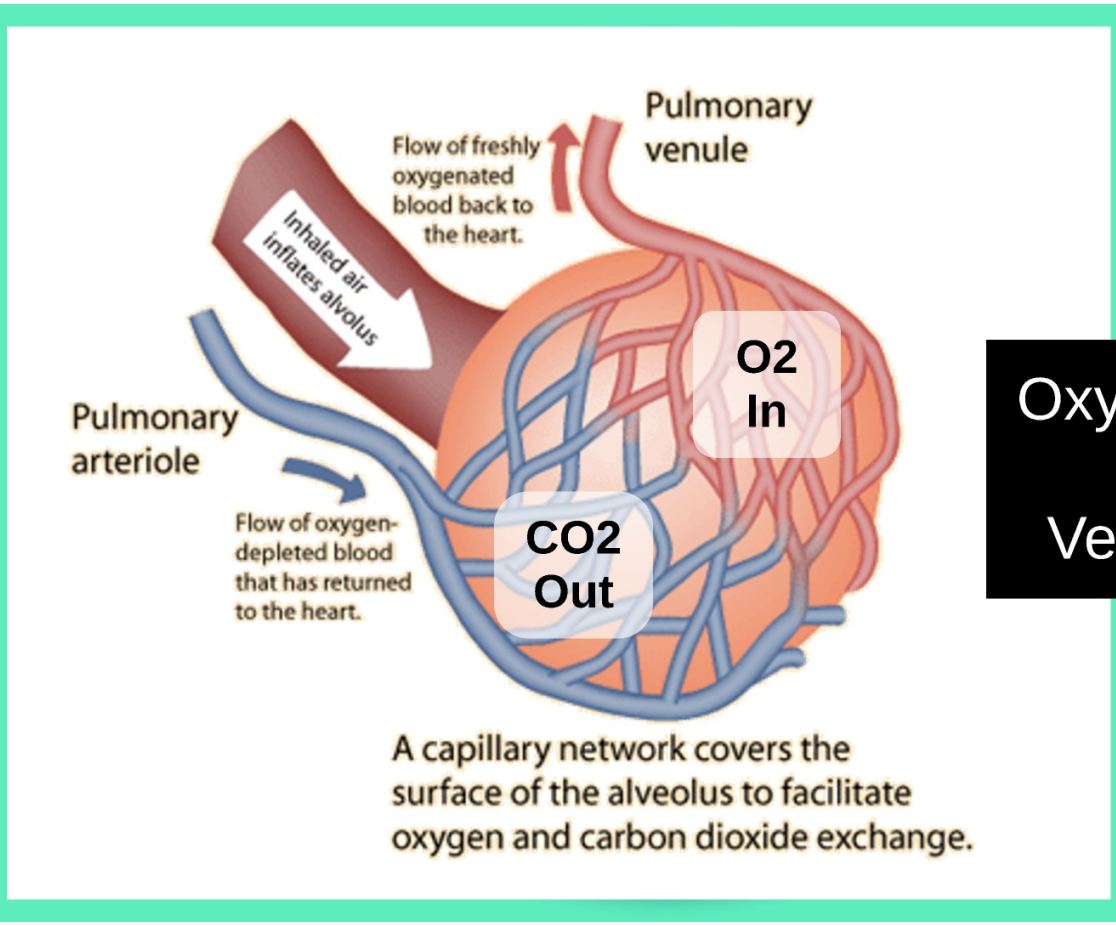
West Zones



COMPLIANCE VS RESISTANCE

VENTILATION/ PERFUSION





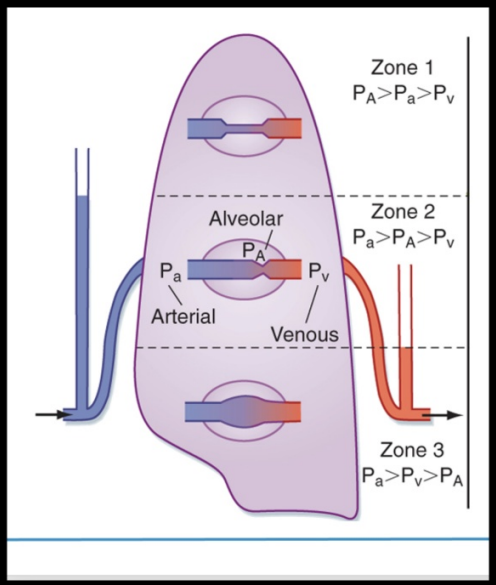
Oxygenation *and* Ventilation

GAS EXCHANGE

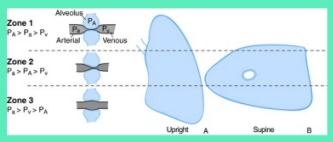
COMPLIANCE VS RESISTANCE

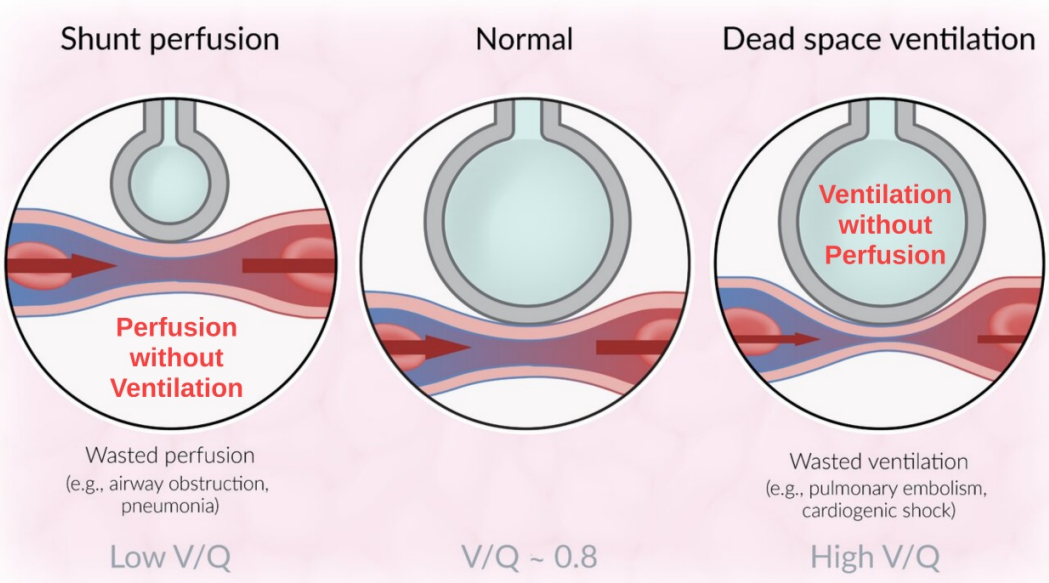
PATHOPHYSIOLOGY

West Zones



VENTILATION/ PERFUSION





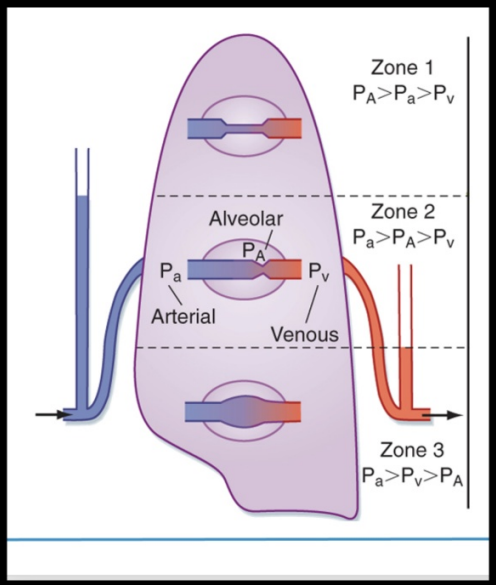
V/Q MATCHING

GAS EXCHANGE

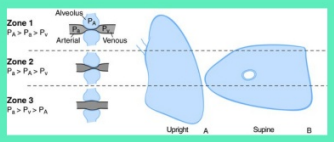
COMPLIANCE VS RESISTANCE

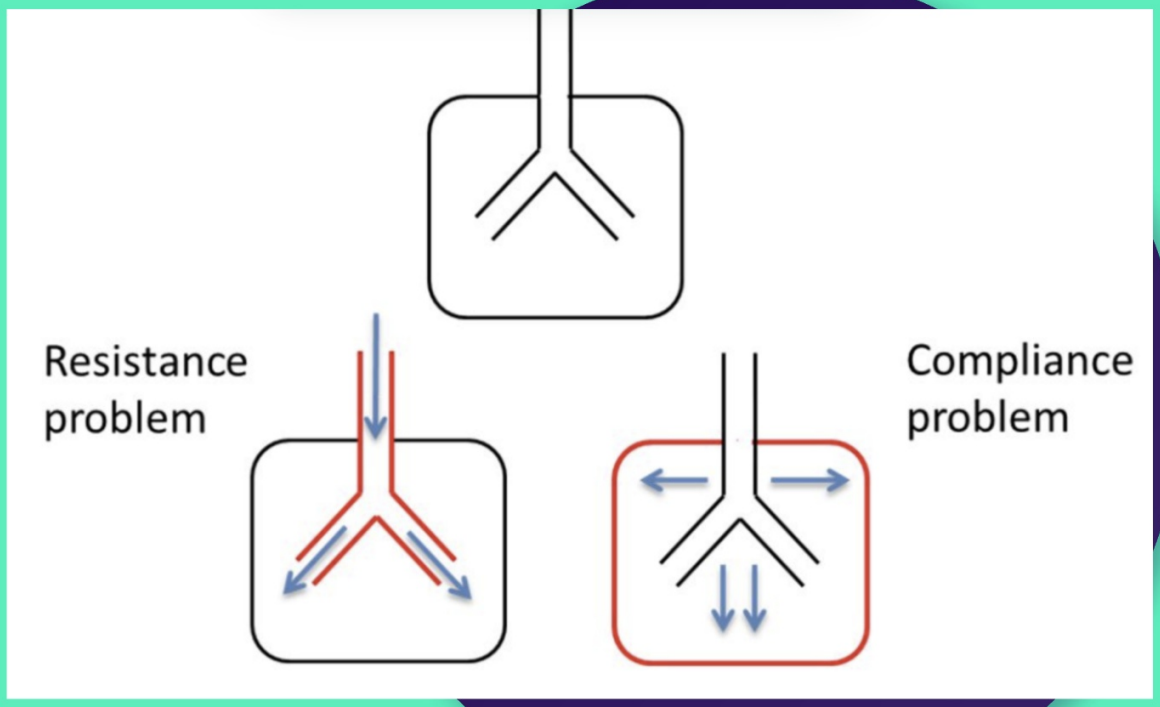
PATHOPHYSIOLOGY

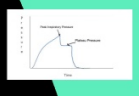
West Zones



VENTILATION/ PERFUSION



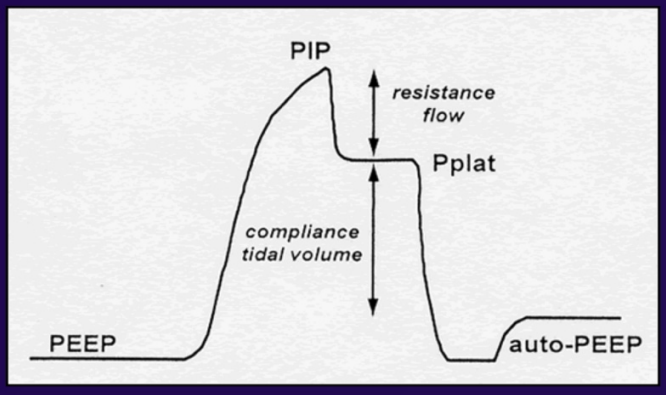




INSPIRATORY & PLATEAU

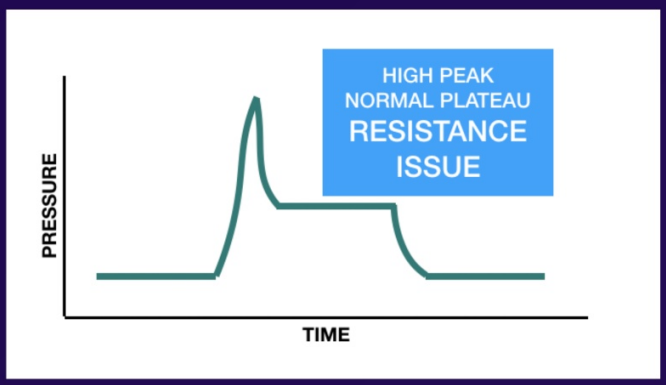
COMPLIANCE

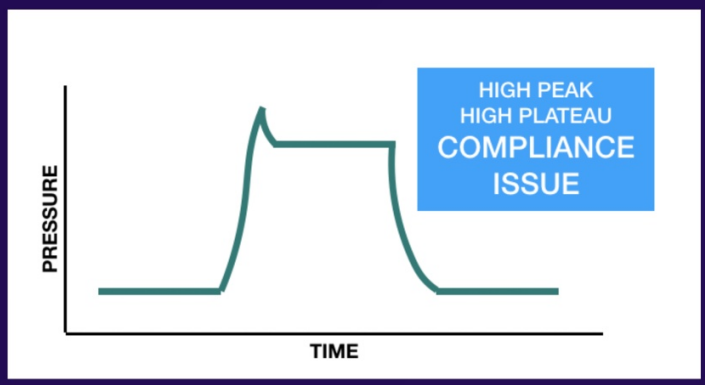
Volume change per unit pressure
Lungs are very compliant

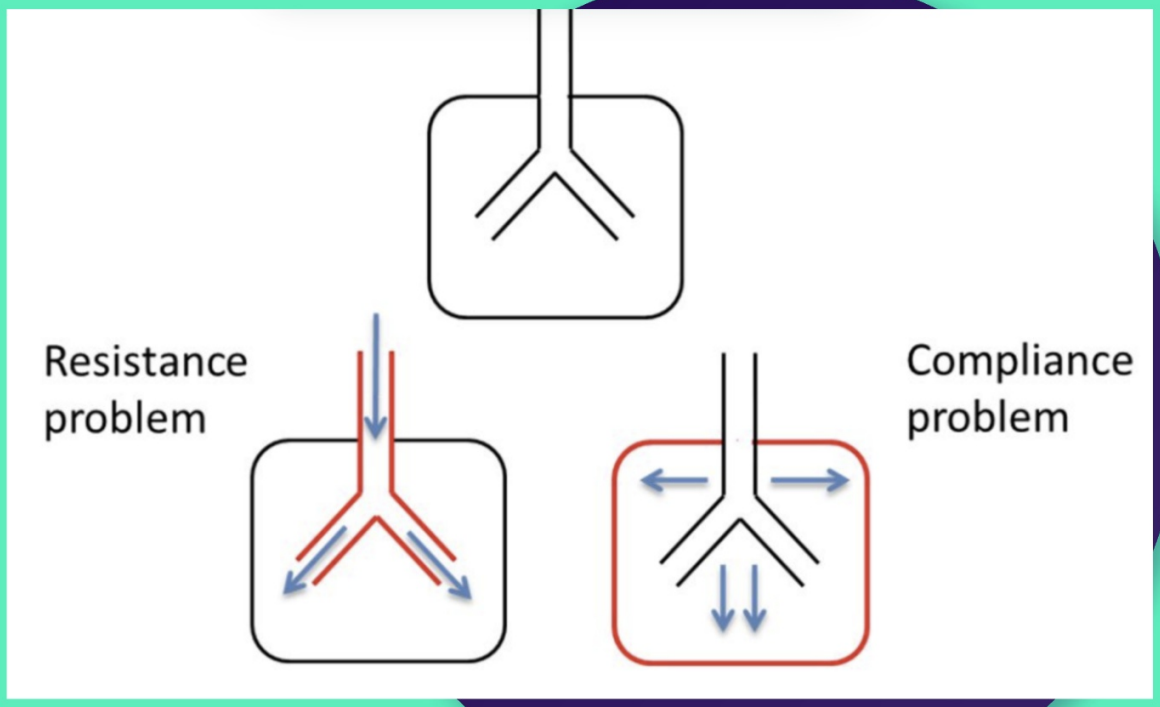


RESISTANCE

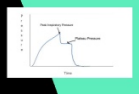
Change in transpulmonary pressure needed to produce flow of gas







INSPIRATORY & PLATEAU

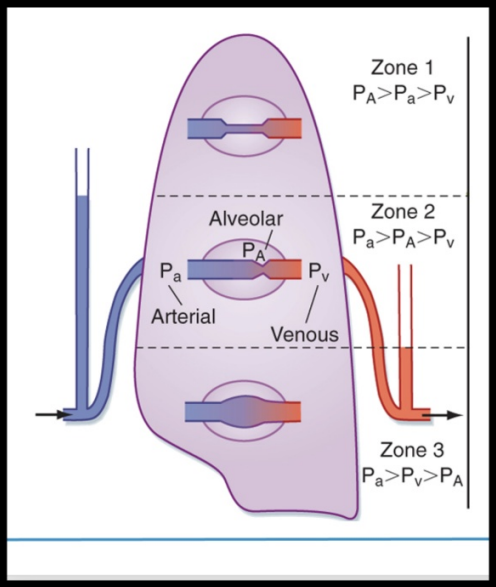


PATHOPHYSIOLOGY

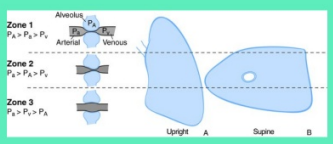
GAS EXCHANGE

COMPLIANCE VS RESISTANCE

West Zones



VENTILATION/ PERFUSION



DISCLOSURE/ OBJECTIVES

REFERENCES

VENTILATION MODALITIES: THERE ARE SO MANY TO USE!

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

HISTORY

PATHOPHYSIOLOGY REVIEW

BASICS OF MECHANICAL VENTILATION

MODES OF VENTILATION

STRATEGIES

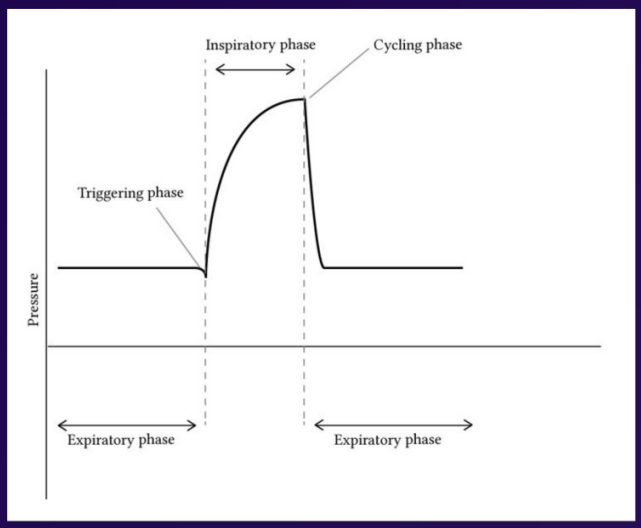
ICU VS. ANESTHESIA

Considerations

Comorbidities
+
Anesthesia Type
+
Positioning
+
Procedure
+
Pharmacology

TERMS

VARIABLES



PHASE VARIABLE

TRIGGER VARIABLE

CYCLE VARIABLE

PHASE VARIABLES

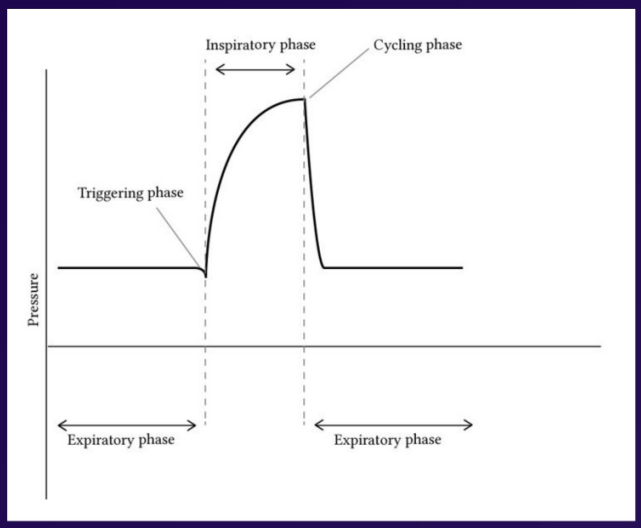
4 phases:

1) Change from expiration to inspiration
2) Inspiration
3) Change from inspiration to expiration
4) Expiration

Variables measured

Pressure
Volume
Flow
Time

VARIABLES



PHASE VARIABLE

TRIGGER VARIABLE

CYCLE VARIABLE

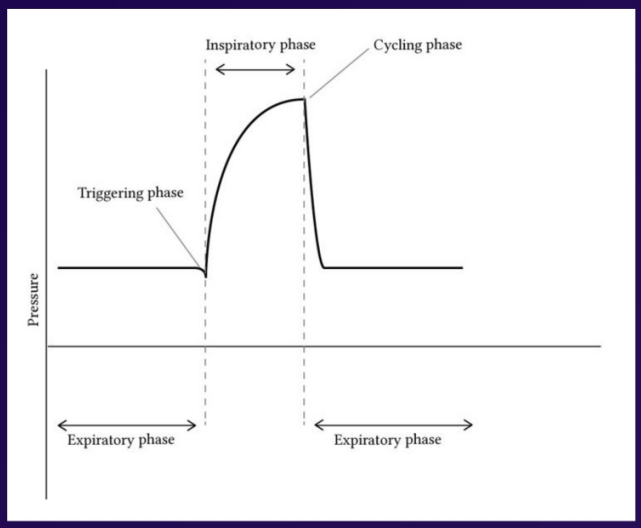
TRIGGER VARIABLE
(Initiates inspiration)

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

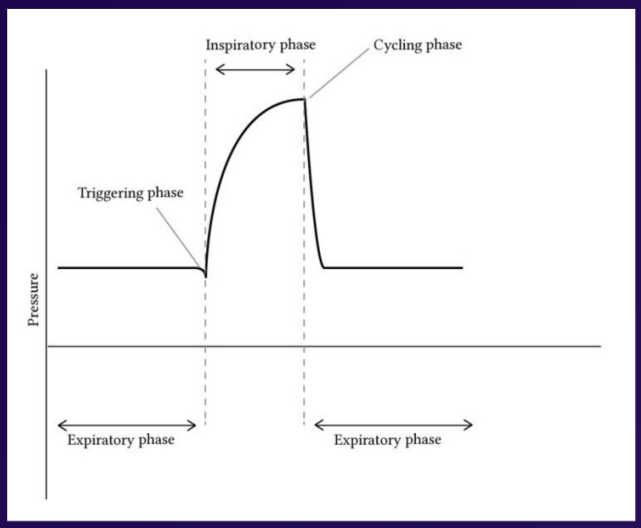
Pressure
Preset pressure is reached

Volume
Preset volume flows through ventilator valve

Flow
Delivers flow until preset level is reached (PSV)

Time
Preset inspiratory time cycle as elapsed

VARIABLES



PHASE VARIABLE

TRIGGER VARIABLE

CYCLE VARIABLE

ICU VS. ANESTHESIA

Considerations

Comorbidities
+
Anesthesia Type
+
Positioning
+
Procedure
+
Pharmacology

TERMS

DISCLOSURE/ OBJECTIVES

REFERENCES

VENTILATION MODALITIES: THERE ARE SO MANY TO USE!

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

HISTORY

PATHOPHYSIOLOGY REVIEW

BASICS OF MECHANICAL VENTILATION

MODES OF VENTILATION

STRATEGIES

MECHANICAL VENTILATION

Targeted end points

Every mode is not for every patient

Understanding nuances is important

Mainly treating O_2 and CO_2

VCV

PCV

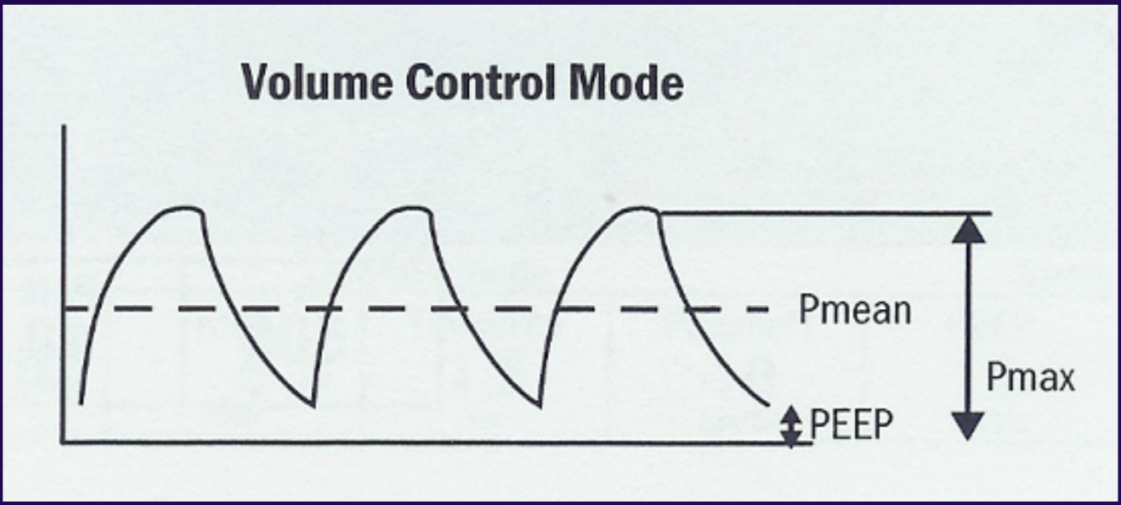
SIMV

PCVG

PSV PRO

CPAP

VOLUME CONTROLLED VENTILATION (VCV)



Key Points

- Volume Limited
- Time Cycled
- Constant Flow

Tidal Volume

on the Ventilator is Based on

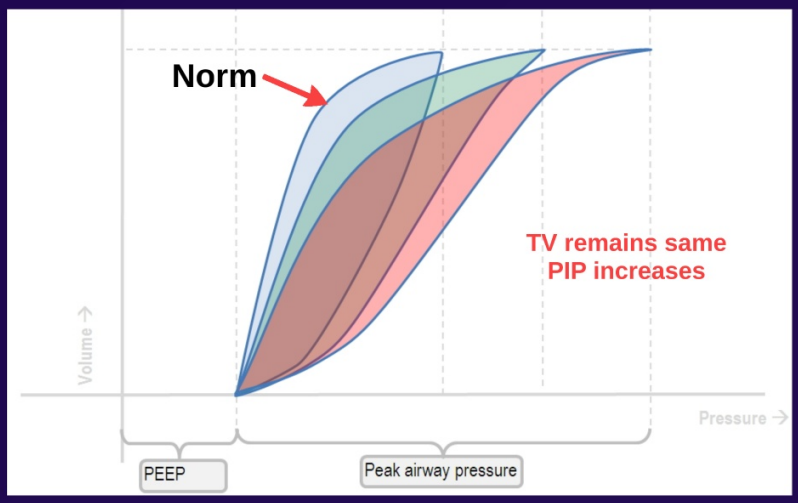
IDEAL BODY WEIGHT

not Actual Body Weight

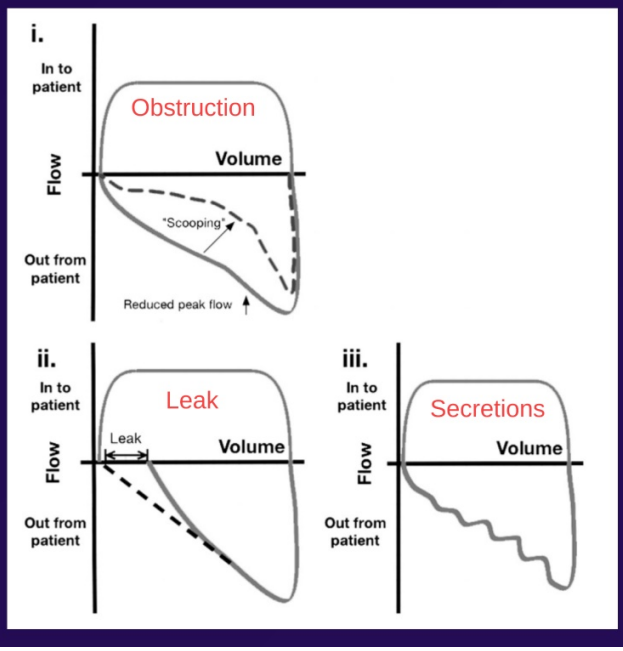
Women: Ideal body weight in pounds = 100 + 5 x (height, in – 60)
Men: Ideal body weight in pounds = 110 + 5 x (height, in – 60)

VOLUME CONTROLLED VENTILATION

Decreased Compliance



Obstruction, Leak, and Secretions



MECHANICAL VENTILATION

Targeted end points

Every mode is not for every patient

Understanding nuances is important

Mainly treating O_2 and CO_2

VCV

PCV

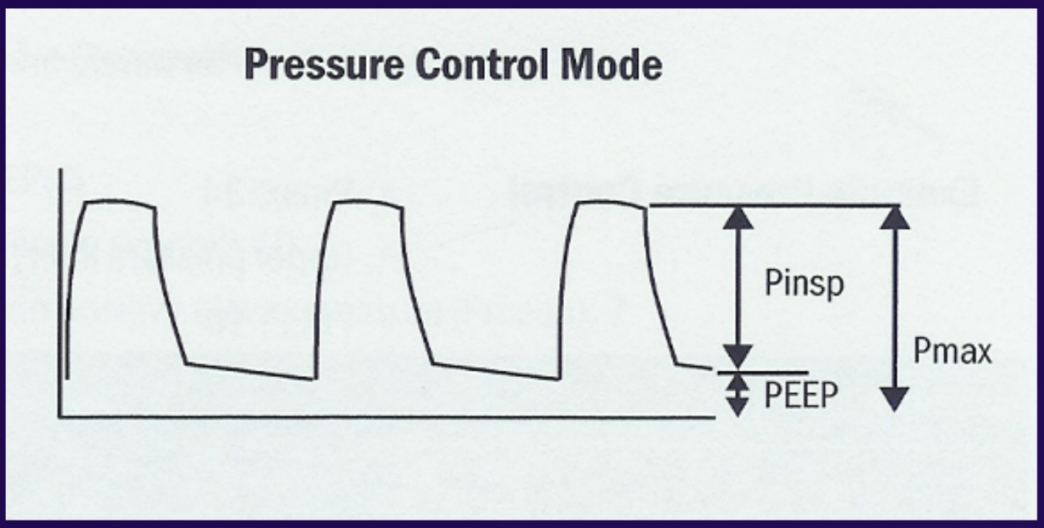
SIMV

PCVG

PSV PRO

CPAP

PRESSURE CONTROLLED VENTILATION (PCV)



Key Points

- Pressure Limited
- Time Cycled
- Decelerating Flow Pattern

MECHANICAL VENTILATION

Targeted end points

Every mode is not for every patient

Understanding nuances is important

Mainly treating O_2 and CO_2

VCV

PCV

SIMV

PCVG

PSV PRO

CPAP

SYNCHRONIZED INTERMITTENT MANDATORY VENTILATION (SIMV)

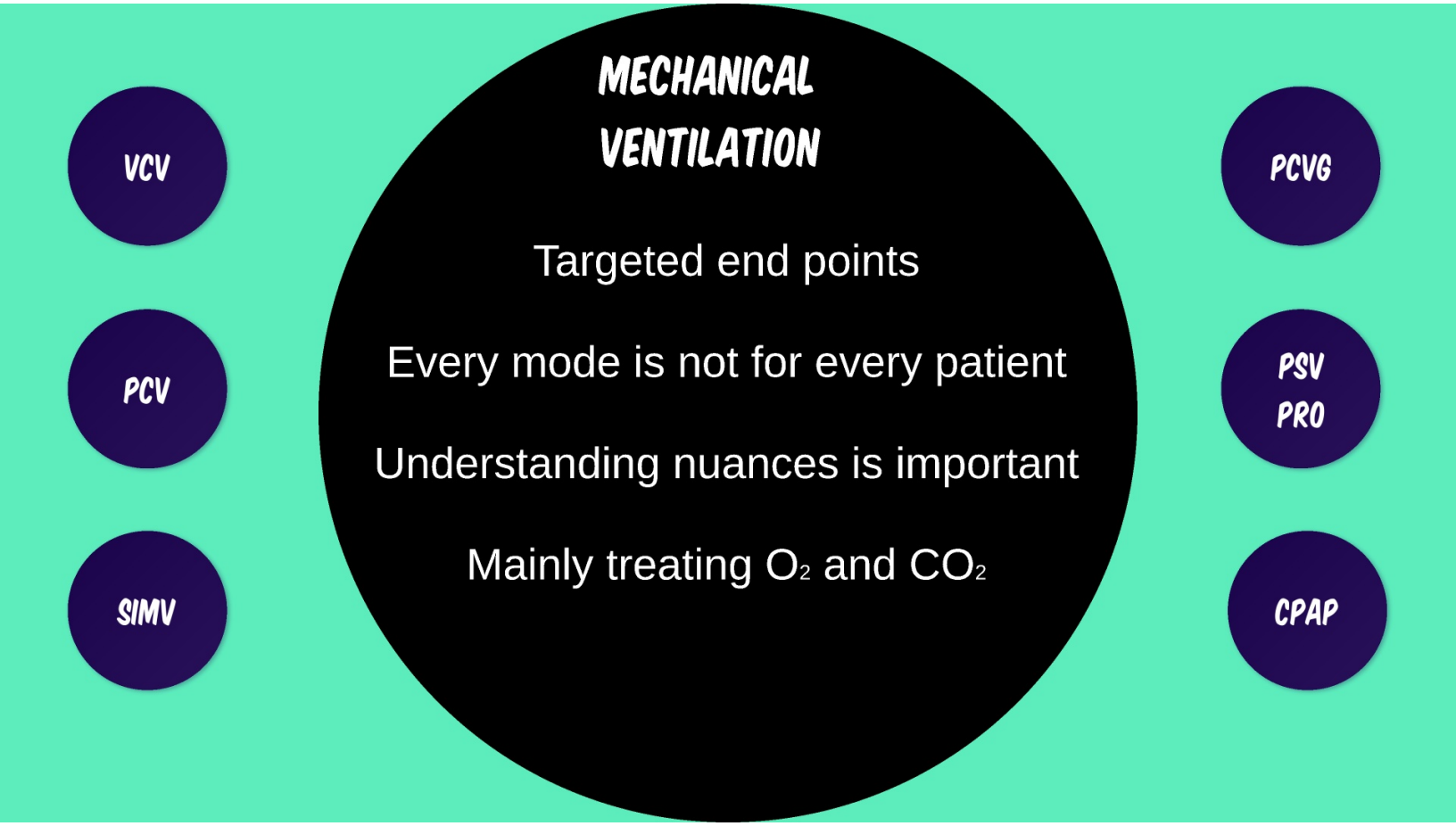
- Spontaneous breathing between mandatory machine cycled breaths supported
- Mandatory breaths VCV or PCV
- Spontaneous breaths supported by pressure support (PS)
- Support can be flow triggered or pressure triggered

Trigger Window

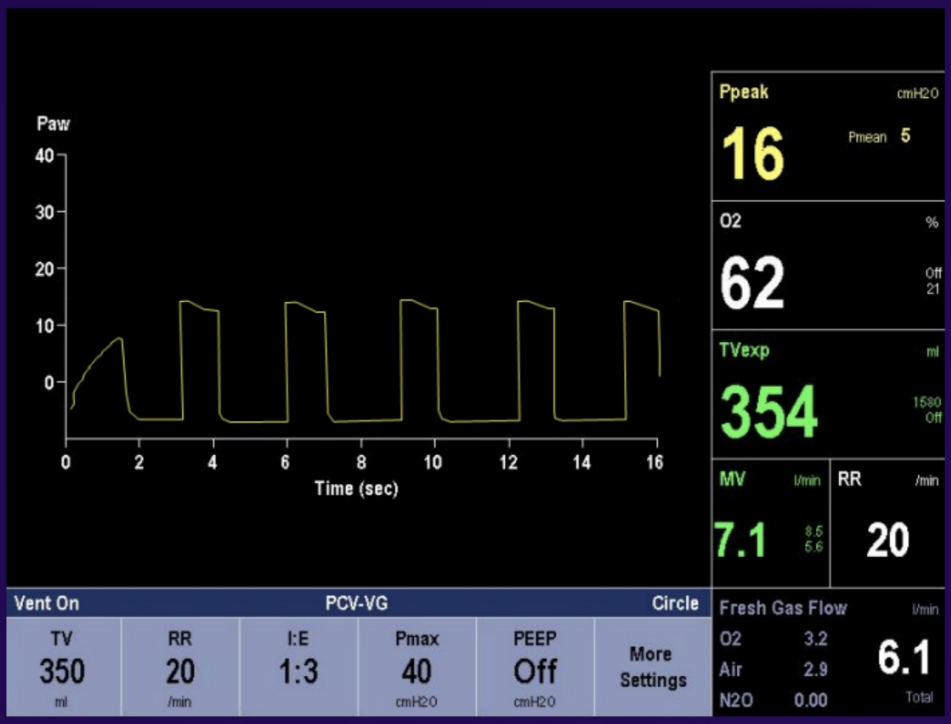
- Amount of time during expiratory cycle that ventilator is sensitive to negative pressure generated by diaphragm

Sensitivity

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



PRESSURE-CONTROLLED VOLUME-GUARANTEED (PCVG)



MECHANICAL VENTILATION

VCV

PCV

SIMV

PCVG

PSV PRO

CPAP

Targeted end points

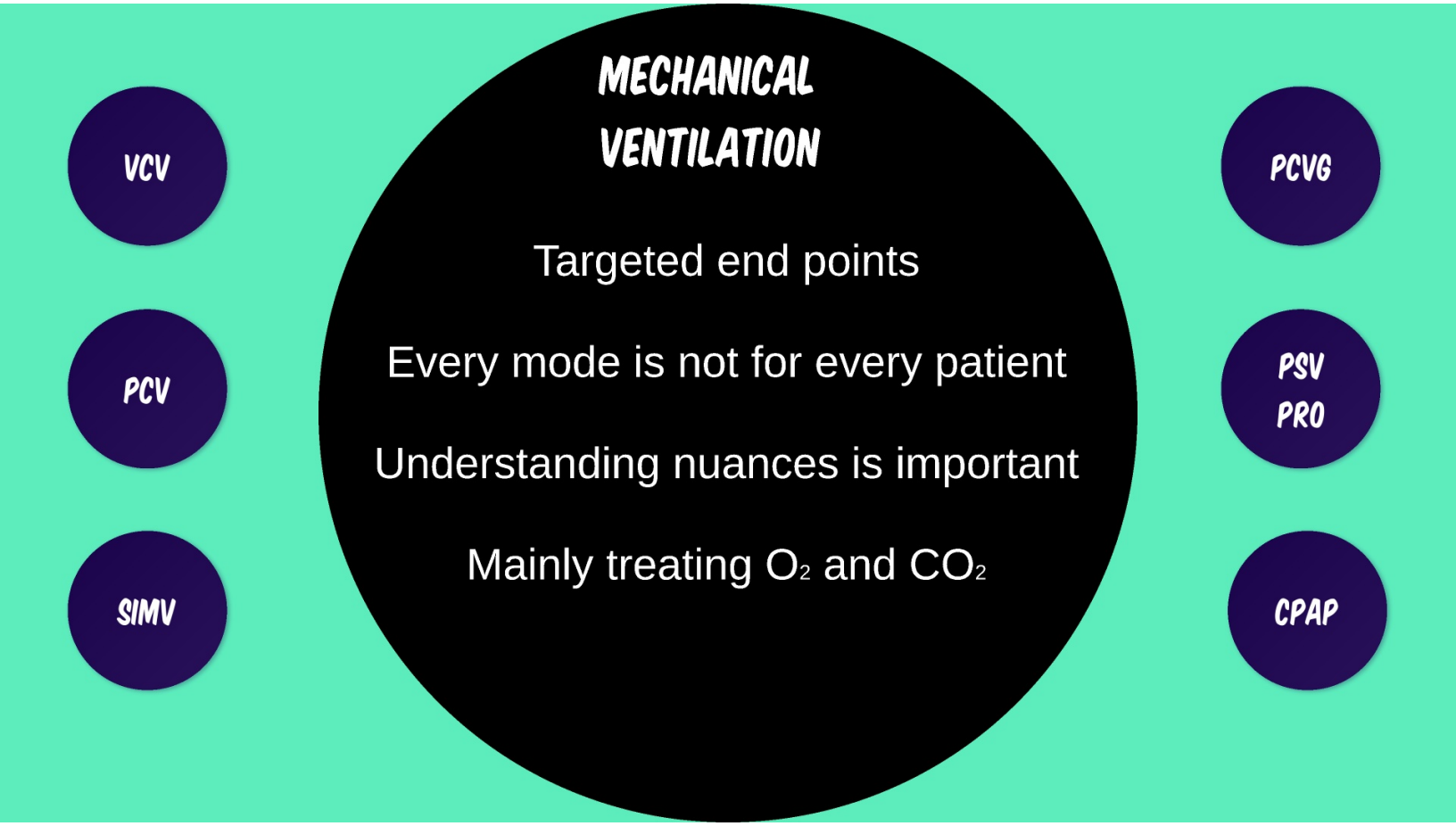
Every mode is not for every patient

Understanding nuances is important

Mainly treating O_2 and CO_2

PRESSURE SUPPORT VENTILATION - PRO (PSV PRO)

- Pressure targeted ventilation
- Responsive to patient's effort
- Augment patient's spontaneous respiration
- Backup mode for apnea (PROtect)
- Weaning, preventing atelectasis, or LMA
-
- Caution with changing trigger window and sensitivity



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
- Help avoid loss of FRC before extubation

MECHANICAL VENTILATION

Targeted end points

Every mode is not for every patient

Understanding nuances is important

Mainly treating O_2 and CO_2

VCV

PCV

SIMV

PCVG

PSV PRO

CPAP

DISCLOSURE/ OBJECTIVES

REFERENCES

VENTILATION MODALITIES: THERE ARE SO MANY TO USE!

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

HISTORY

PATHOPHYSIOLOGY REVIEW

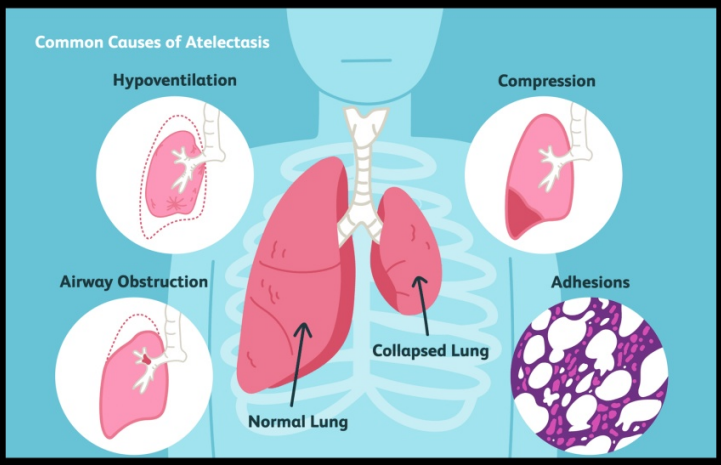
BASICS OF MECHANICAL VENTILATION

MODES OF VENTILATION

STRATEGIES

PEEP

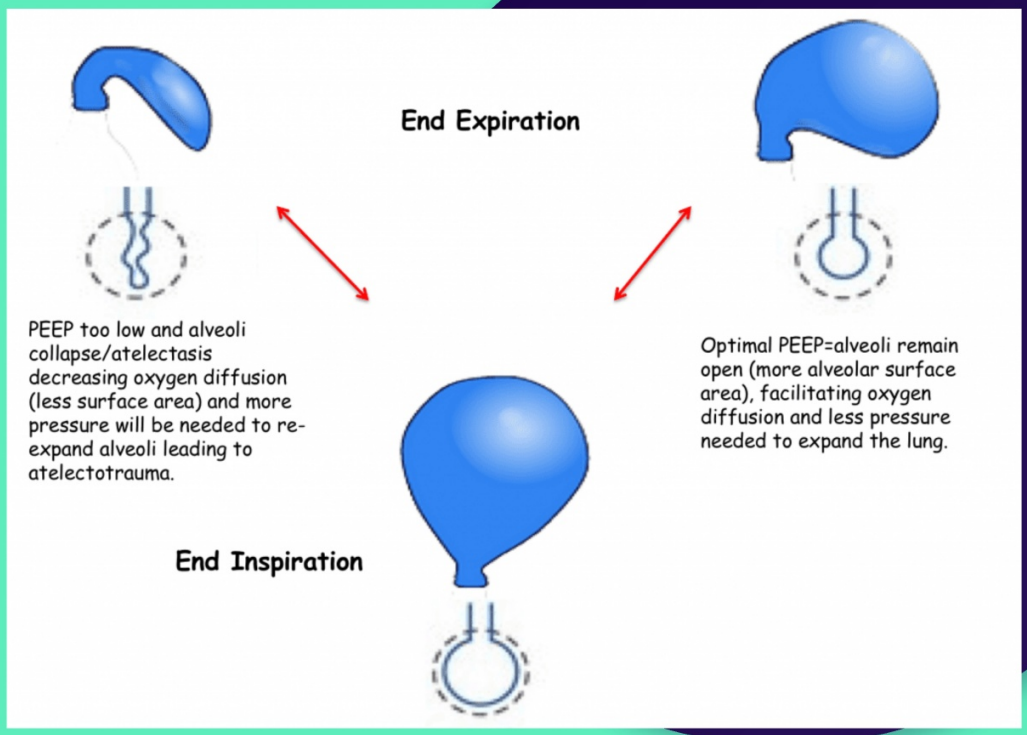
ATELECTASIS

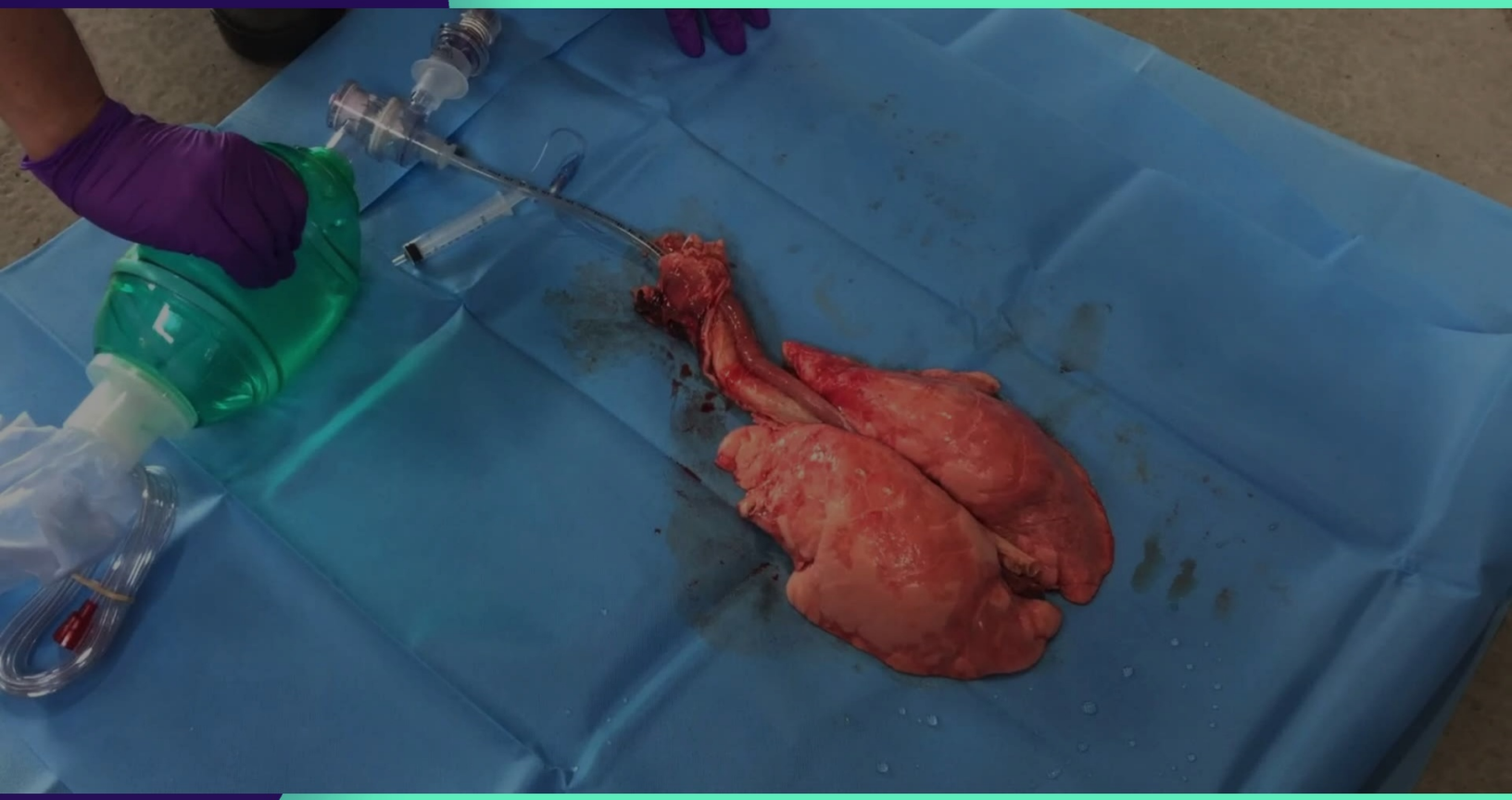


O_2 CONCENTRATION

I:E RATIO

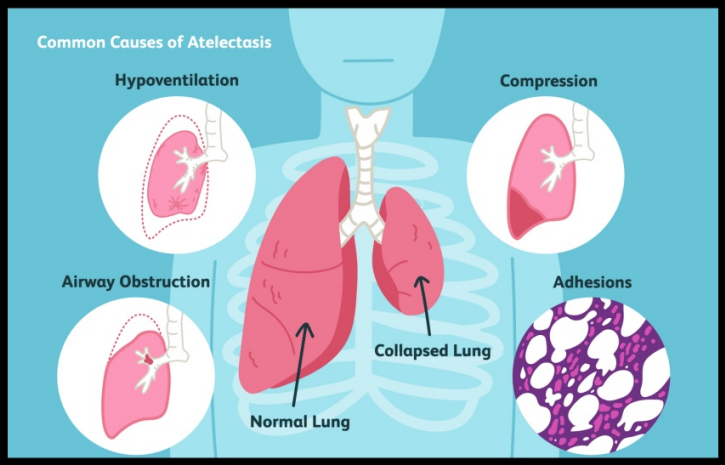
PEEP


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



PEEP

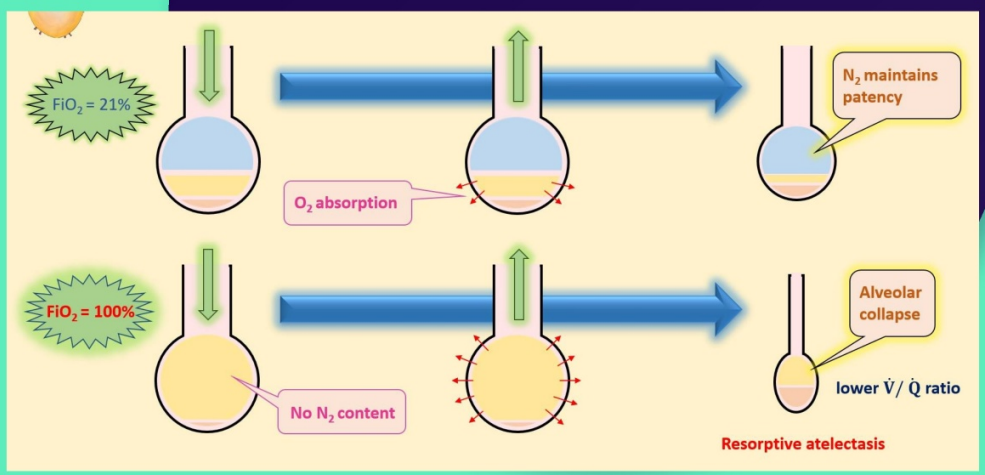
ATELECTASIS



O_2 CONCENTRATION

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%

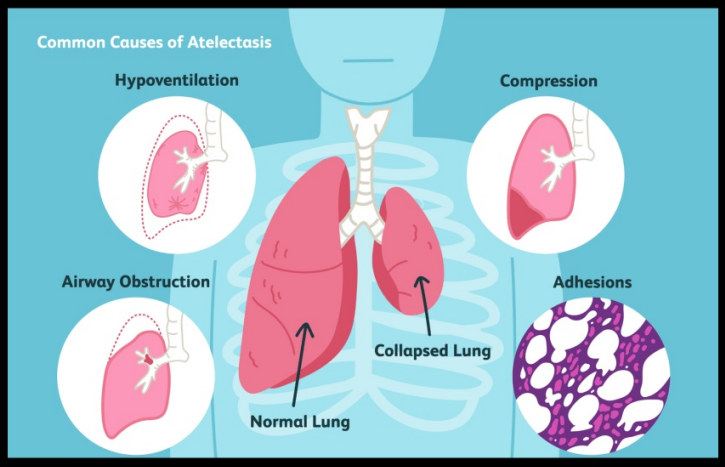
Proxygenate
FiO_2 0.8 = 0.58% atelectasis
FiO_2 1.0 = 6.8% atelectasis

PEEP

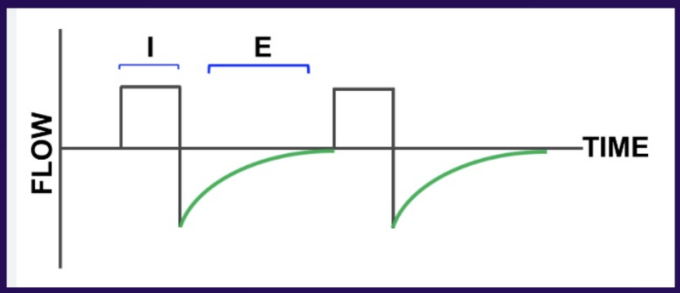
O_2 CONCENTRATION

I:E RATIO

ATELECTASIS



I:E RATIO



Normal I:E is 1:2

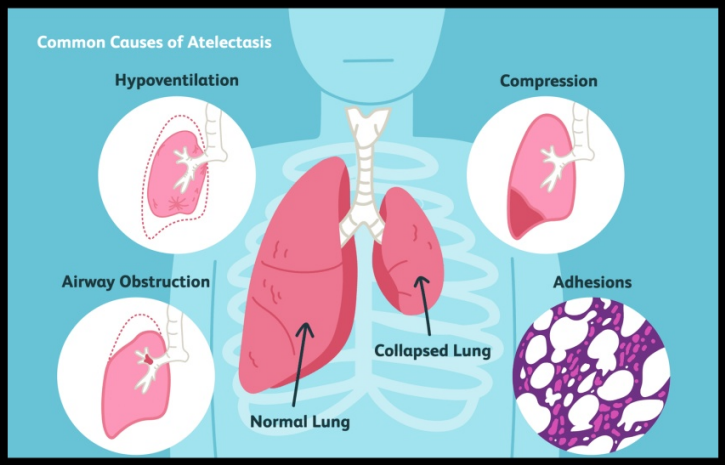
Higher I:E
- beneficial in conditions where it is difficult for air to leave the lungs (*i.e. asthma, COPD*)

Shorter I:E
- used with patients difficult to ventilate
- *monitor for gas trapping*

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

PEEP

ATELECTASIS



O_2 CONCENTRATION

I:E RATIO

VENTILATION MODALITIES: THERE ARE SO MANY TO USE!

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

DISCLOSURE/ OBJECTIVES

REFERENCES

STRATEGIES

MODES OF VENTILATION

BASICS OF MECHANICAL VENTILATION

PATHOPHYSIOLOGY REVIEW

HISTORY

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.

Benoît, Zilgia MD*,; Wicky, Stephan MD†,; Fischer, Jean-François MD‡,; Frascarolo, Philippe PhD*,; Chapuis, Carine MD*,; Spahn, Donat R. MD*,; Magnusson, Lennart MD, PhD*. The Effect of Increased Fio2 Before Tracheal Extubation on Postoperative Atelectasis. Anesthesia & Analgesia 95(6):p 1777-1781, December 2002. | DOI: 10.1097/00000539-200212000-00058

DISCLOSURE/ OBJECTIVES

REFERENCES

VENTILATION MODALITIES: THERE ARE SO MANY TO USE!

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

STRATEGIES

MODES OF VENTILATION

BASICS OF MECHANICAL VENTILATION

PATHOPHYSIOLOGY REVIEW

HISTORY

NEW·JERSEY·ASSOCIATION OF·NURSE·ANESTHETISTS
est. NJANA 1939