APRV: An Update

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Disclosures

- No conflicts of interest

Objectives

- Attendees will be able to:

- Define the mechanism of APRV
- Describe the application of APRV and understand basics of settings
- Discuss some recent literature supporting the use of APRV

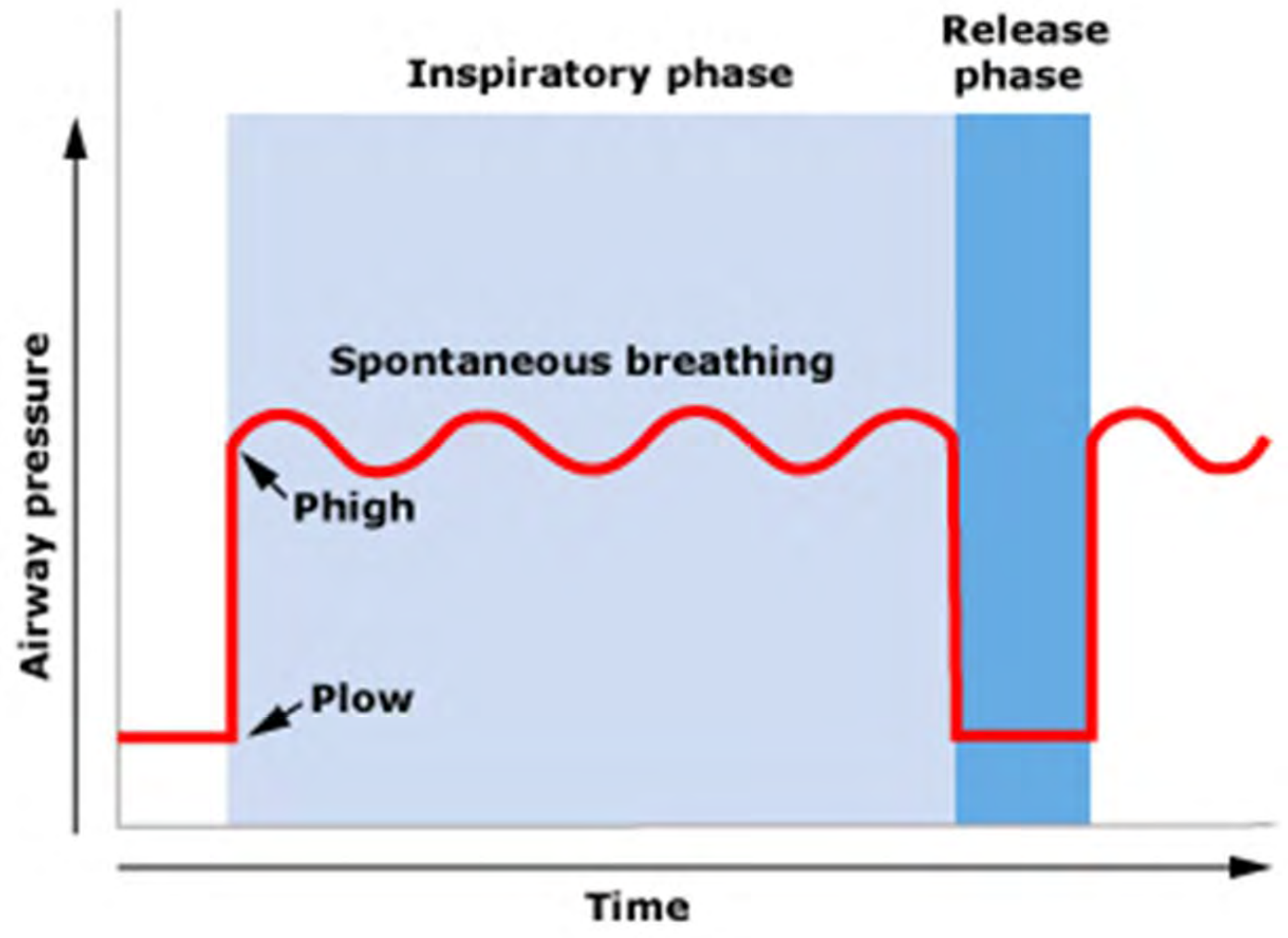
Airway Pressure Release Ventilation (APRV)

- Mode of mechanical ventilation utilizing elevated CPAP with intermittent timed pressure release
- Pressure-limited, time-cycled mode
- Open lung mode of ventilation
  - Spontaneous breathing at any point in the cycle
- Inverted I:E ratio
- Used primarily as salvage mode for oxygenation

APRV

- APRV (Dräger Evita, Savina and V series, Hamilton G5)
- Bi-Vent (Maquet Servo-i),
- BiLevel (Engström Carestation, Puritan Bennett 840 & 980)
- APRV/Biphasic (Viasys Avea)
- DuoPAP (Hamilton)

- Very similar to BIPAP mode (Europe)


Inspiratory phase
Release phase
Spontaneous breathing
Phigh
Plow
Airway pressure
Time

Goals

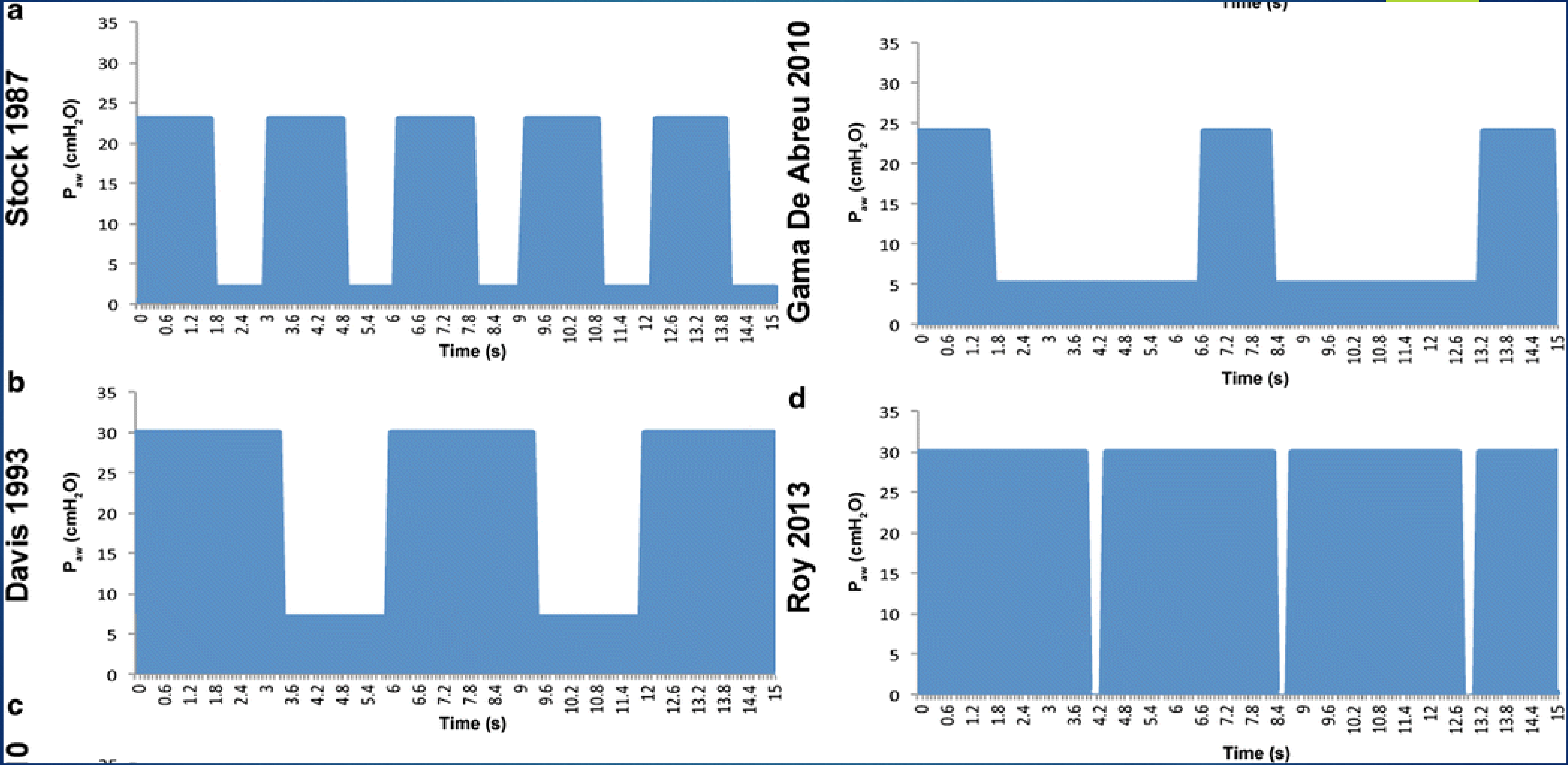
- Acute lung injury (ALI/ARDS)
- Low compliance and high pressure situations

- Lung protective/Low Vt ventilation
- Minimize alveolar collapse/re-expansion
- Minimize alveolar overdistention
  - Heterogenous filling
- Restore and maintain FRC with recruitment and PEEP

History

- Created 1987 by Stock & Downs
- Not commercially available until the mid 1990s
- Maintained CPAP allowing spontaneous breaths without significant airway pressure fluctuation and a brief cyclic release phase for efficient ventilation (i.e., CPAP with release)
- Simple definition allows much variability and definition for studies
  - Limited comparison between studies due to variability
  - Different settings and mechanics greatly change how the breath is "seen" by the lungs

Downs JB, Stock MC (1987) Airway pressure release ventilation: a new concept in ventilatory support. Crit Care Med 15:459–461



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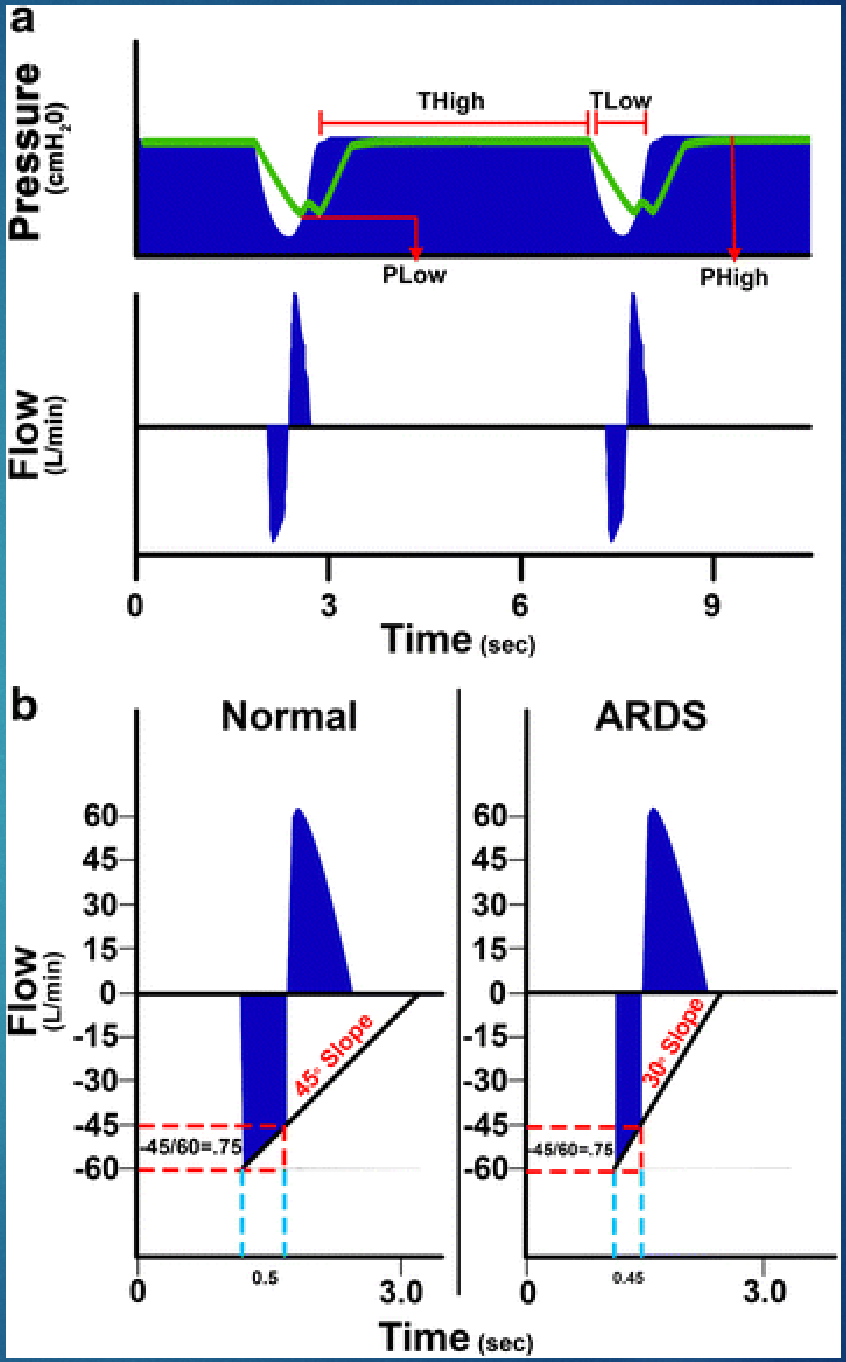
Types of APRV

- Fixed (F-APRV) and Personalized (P-APRV)
  - Fixed: T-high makes up <90% of cycle time with fixed T-low that doesn't change with lung mechanics
  - Personalized: P-high set to desired P-plateau, T-high set to 90% of cycle time, T-low set based on lung mechanics/slope of expiratory flow curve, and P-low set at 0 (minimize convective expiratory gas flow resistance and maximize ventilation while maintaining PEEP)
    - EEF/PEF ~0.75

Habashi NM (2005) Other approaches to open-lung ventilation: airway pressure release ventilation. Crit Care Med 33:S228–S240

P-APRV

- T-high ~90% of breath cycle
- T-low short
- EEP never fully reaches 0 (tracheal pressure green line)
- Adaptive adjustment of T-low for EEF/PEF ratio 0.75 to 0.5



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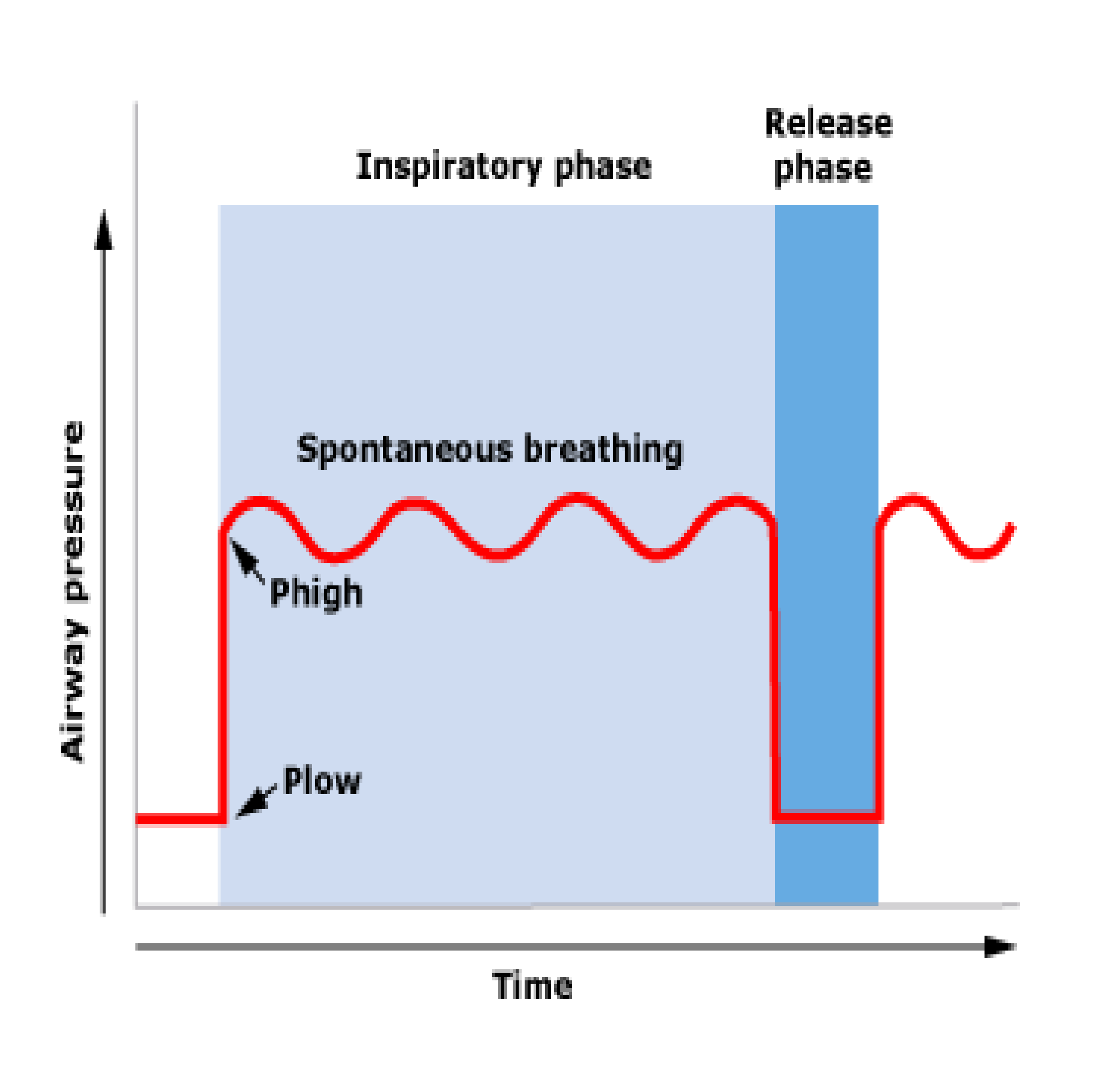
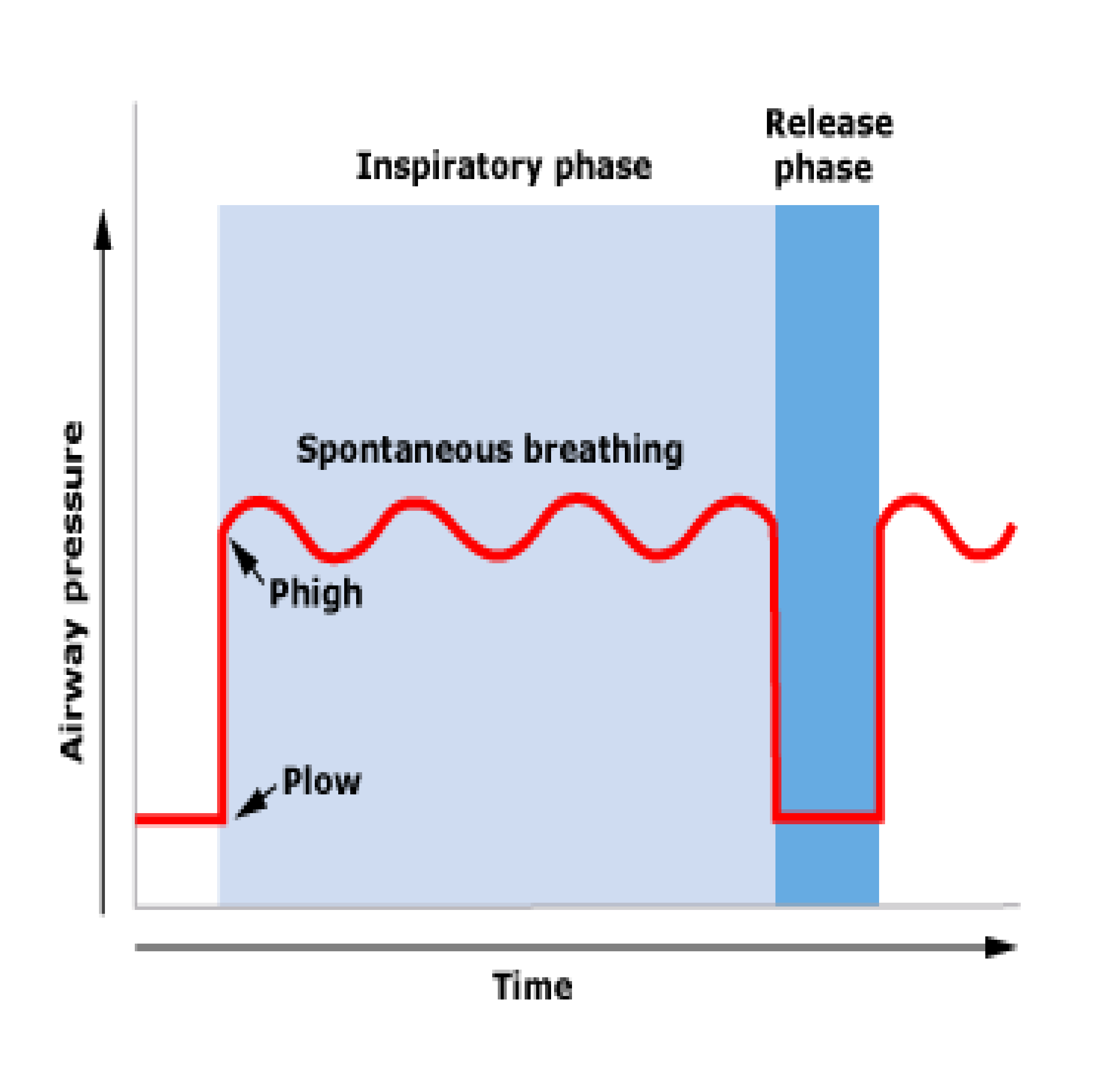
Mechanics

- P-low to P-high is inspiratory phase
  - Inflates lung
  - Drives alveolar recruitment
  - Maximizes MAP, Oxygenation
- Release phase
  - Exhalation
  - Elimination of CO2
- ΔP = driving pressure
  - Greater difference = larger Vt



Mechanics

- Spontaneous breathing at any point in cycle
  - Elimination of CO_2
  - Most at P-high due to duration
- Use of high CPAP leads to restoration of lost FRC (in the setting of reduced compliance)
  - Facilitates improvement of the pressure volume curve and improved ventilatory parameters
- Open lung approach
  - Avoids repeated inflation/deflation of alveoli



Spontaneous Breathing

- Available at any point in cycle of APRV
- Patient controlled respiratory frequency and volumes
- Limits sedation needs
- Improved synchrony
  - Major difference between APRV and other IRV modes

To Add PS or Not To Add PS

To Add PS or Not To Add PS

- NO

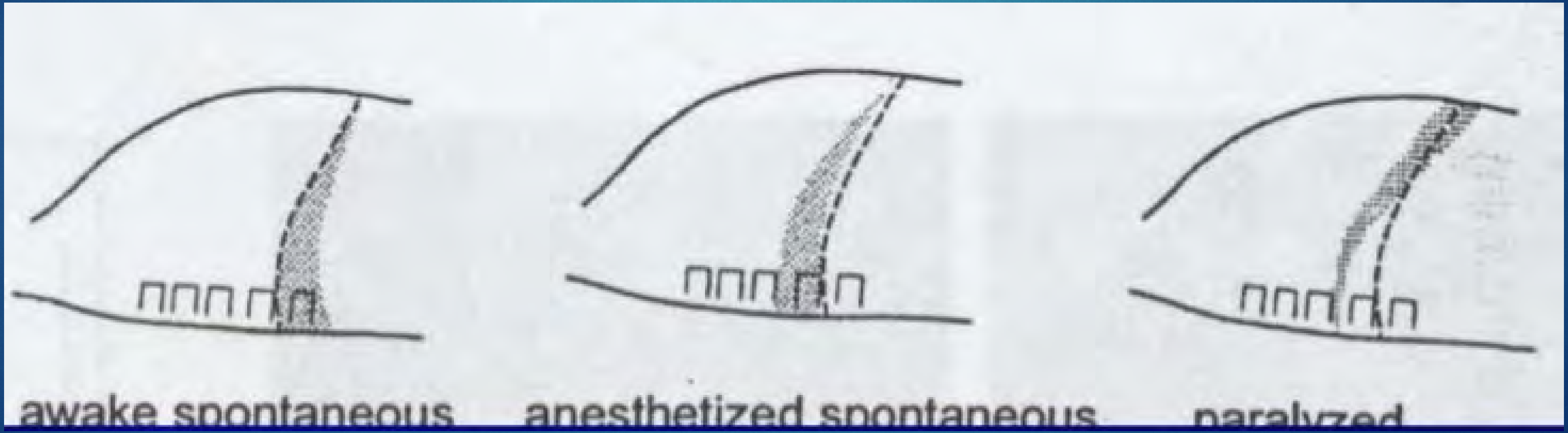
To Add PS or Not To Add PS

- Spontaneous breathing only accounts for 10-30% of ventilation in APRV
- Cyclical breathing with negative pressure effort (No PS)
  - Decreased intrathoracic pressure, improved venous return, improved cardiac output/index
  - Higher O2 delivery and mixed venous saturations
  - Improved vasopressor use
- Improves dependent lung recruitment and VQ matching
- Preserves diaphragmatic strength
- Minimizes atelectasis in the near diaphragmatic and dependent spaces

Kaplan LJ, Bailey H, Formosa V. Airway pressure release ventilation increases cardiac performance in patients with ALI./ARDS. Crit Care. 2001 Aug; 5(4):221-6.
Modrykamien, A. Airway Pressure Release Vetilation: An alternative mode of mechanical ventilation in ARDS. Cleveland Clinic J of Med. 2011 Feb; 78(2): 101-10

Ventilation in the Dependent Lung

- Diaphragm movement and ventilation in spontaneous, positive pressure, and paralyzed lung
- Negative pressure breathing recruits best VQ matched lung



Pressure support

- If you must use it, P-high must be decreased to maintain peak pressures <30-35
  - Set from P-low or drop P-high and add
- Follow for evidence of overdistention, lung injury
- Increased risk of pneumothorax/pneumomediastinum
- With use of Pressure Support must follow:
  - Trigger, requires synchronization
  - T-low alterations
  - Variable volumes and volume loss/alveolar collapse

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Challenges

- Control of parameters and proper waveform assessment for adjustment
- Deviation from original concept of CPAP with timed release
- Non-standard usage and settings
- Use of Pressure Support

APRV

Benefits

- Improved oxygenation with decreased peak airway pressure
- Improved dead space ventilation
- Improved alveolar recruitment and FRC
- Decreased sedation needs
- Improved VQ match and decreased shunting
- Improved venous return and CO

Risks/Drawbacks

- Dyssynchrony
- Loss of benefit with heavy sedation and/or paralysis
- Auto-PEEP
- Hemodynamic instability in susceptible patients
- High airway resistance
- Volutrauma/stretch injury

APRV Settings

APRV Starting Points

- P-high
  - At plateau or slightly above desired MAP
  - 26-30cm H_2O
  - Keep below 35cm H_2O (as possible)
- T-high
  - 4-6 seconds
  - RR 8-15

APRV Starting Points

- P-low
  - 0
  - Can use low PEEP if using BIPAP style mode with longer T-low
- T-low
  - 0.4-0.8 seconds
  - Should terminate breath when EEF/PEF ratio 0.75 to 0.5
- FiO2
  - 1.0
- PS
  - NONE

APRV titration

- Oxygenation
  - FiO2
  - MAP
    - Increase P-high
    - Decrease T-low
- Hypercapnia
  - Increase P-high
  - Lengthen T-low (do not drop EEF/PEF ratio below 0.25)
  - Increase T-high to allow more spontaneous breaths
  - Decrease T-high to allow more releases
- Hyperventilation
  - Decrease P-high
  - Increase T-high to decrease number of releases

APRV titration

- Increased work of breathing
  - Increase P-high to increase MAP/Recruitment
  - Decrease T-low to maximize FRC
  - Decrease P-high and increase T-high
    - Maintains MAP but decreases overdistention

APRV Weaning

- Wean FiO2
  - Goal is <0.5
- Drop and stretch (transition to CPAP with spontaneous breathing)
  - Simultaneous changes:
  - Decrease P-high
    - Increments of 2cm H2O
    - Goal <20 cm H2O
  - Increase T-high
    - Decreased number of releases
    - Goal >10 secods
  - Once at adequate pressures, transition to VCV or PCV with high PEEP

Current Status of APRV

- Paucity of data
  - Non-comparable studies
  - Non-standardized definitions and settings
- Study types limited
  - Almost entirely crossover or retrospective data
- APRV is a divided name with very different mechanics and breath styles
  - F-APRV inferior to P-APRV in protective mechanics for the lung

Rose L, Hawkins M (2008) Airway pressure release ventilation and biphasic positive airway pressure: a systematic review of definitional criteria. Intensive Care Med 34:1766–1773
Facchin F, Fan E (2015) Airway pressure release ventilation and high-frequency oscillatory ventilation: potential strategies to treat severe hypoxemia and prevent ventilator-induced lung injury. Respir Care 60:1509–1521

Current Status of APRV

- Well proven to be non-inferior
  - Putsenen et al. – improved sedation needs, increased oxygenation, CI, and pulmonary compliance. No change in mortality or ventilator free days
  - Varpula et al. – similar mortality and ventilator free days, APRV group with higher disease acuity
  - Maxwell et al. – no change in mortality, ventilator free days, or complication rates despite APRV group with high baseline disease severity

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Current Status of APRV

- Possibly superior
  - Hanna et al. – improved P/F ratio, procurement rate, and graft survival in donor lungs
  - Davies et al. – improved oxygenation with decreased cerebral ischemia in TBI
  - Andrews et al. – decreased incidence of ARDS and mortality in trauma patients compared to traditional PPV
  - Hussain et al. – earlier hemodynamic stability in septic shock patients

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Conclusions

- APRV, when used optimally is an adaptive, flow directed, duration dependent mode of ventilation that can be modified for patients with multiple lung pathologies
- It has similar mortality, ICU day, and ventilator day outcomes to traditional low Vt ventilation in ARDS (non-inferior), but has not been proven superior
  - Slow adoption
- The "definition" of the mode is still in flux and being debated
- Lack of familiarity with the physiology may result in maladjustment and loss of the benefits of the mode
- NEEDS MORE RESEARCH


ANY
QUESTIONS
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