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)
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

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

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

Mechanics

- P-low to P-high is inspiratory phase
  - Inflates lung
  - Drives alveolar recruitment
  - Maximizes MAP, Oxygenation
- Release phase
  - Exhalation
  - Elimination of CO2
- $\Delta P = \text{driving pressure}$
  - Greater difference = larger Vt
Mechanics

- Spontaneous breathing at any point in cycle
  - Elimination of CO2
  - 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

Modrykamien, A. Airway Pressure Release Ventilation: 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

Modrykamien, A. Airway Pressure Release Ventilation: An alternative mode of mechanical ventilation in ARDS. Cleveland Clinic J of Med. 2011 Feb; 78(2): 101-10
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 H2O
  - Keep below 35cm H2O (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 seconds
  - 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

Current Status of APRV

- Well proven to be non-inferior
  - Putsenem 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
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
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?