Policy #:	25.01.153
Issued:	4-1-2006
Reviewed/ Revised:	10-11-2006
Section:	Respiratory Care

Airway Pressure Release Ventilation

Description/Definition

Airway Pressure Release Ventilation (APRV) is the application of Continuous Positive Airway Pressure (CPAP) to maintain spontaneous breathing with an optimal functional residual capacity (FRC) for alveolar capillary gas exchange with the addition of occasional pressure releases to augment CO2 removal. A high and low CPAP level is set with releases from the high CPAP level to the low CPAP level. The CPAP levels primarily facilitate oxygenation and the timed releases facilitate carbon dioxide clearance. Spontaneous breathing may occur at any time during the cycle enabling the patient to augment throughout the respiratory cycle.

Advantages

Spontaneous breathing

Better dependant ventilation
Decreased requirement for sedation/paralytics
Improved muscle tone
Shorter vent days
Control of peak airway pressures
A continuous lung recruitment maneuver

Indications

- Mechanical ventilation – (exclusive of contraindications)
- Acute lung injury, acute respiratory disease syndrome and other forms of acute restrictive disease that involves recruitable lung elements.

Relative Contra-indications – Obstructive airway disease – (Obstructive airway disease shall be defined as the inability for the expiratory flow to decrease to 50% of the peak expiratory flow in 1.0 seconds.) See figure 1.

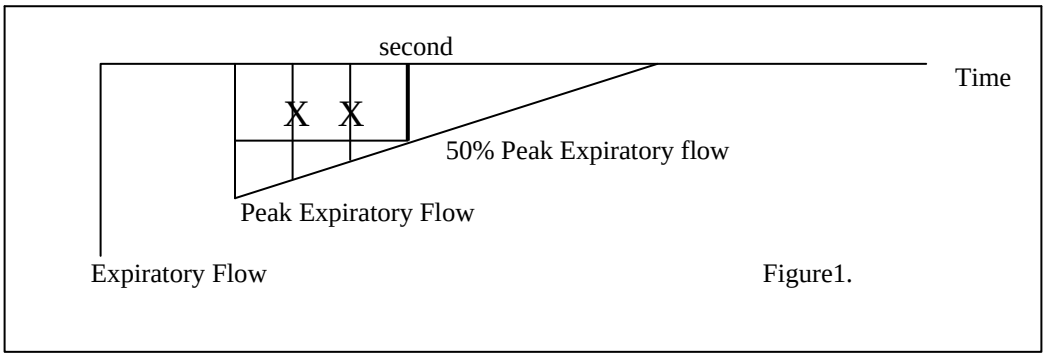

Figure1.

Patients with obstructive lung diseases may need to have Time Low set as high as 1.5 seconds to allow for adequate exhalation.

Initiation

Adult

Newly intubated patients:

P_{High} Initial setting at desired plateau level, typically 20-25cmH_2O
Normally, the maximum goal for P high is 35cmH2O. Limiting the P high to 35cmH2O may minimize ventilator associated lung injury. However, a P high of > 35cmH2) may be necessary in patients with decreased thoracic and abdominal compliance

P_{Lo} Generally set at 0 (allows for unimpeded exhalation)

T_{High} While the target T_{High} may be 4 - 6 seconds. T_{High} may initially need to be set as short as 1.0 - 3.0 seconds, allowing for an adequate number of releases per minute to achieve the targeted MV. T_{High} should be increased to a goal of 4 – 6 seconds to maximize lung recruitment

T_{Low} This will generally be around 0.5 – 0.8 seconds. Set to achieve an End Expiratory Flow Rate termination that is 25 - 50%, not greater than 75% of peak expiratory flow. T_{Low} generally remains unchanged once set. For obstructed lung disease may need to set as high as 0.8 - 1.5 seconds

Transition from volume/pressure ventilation:

P_{High} **transition from volume ventilation;** set at plateau pressure
transition from pressure ventilation; 3 - 5cmH_2O above mean airway pressure

P_{Low} set at 0

T_{High} initial setting; use current total cycle time minus T Low, (total cycle time minus time low will equal T_H), example; tot cycle time = 3 sec. T Low = 0.5 sec, (3.0 - 0.5 = 2.5 sec),
T_H will be set at 2.5 seconds. T High should be increased to 4 – 6 seconds as early as possible to maximize oxygenation and recruitement of the lung, goal is 4- 6 seconds.

T_{Low} This will generally be around 0.5 – 0.8 seconds. Set to achieve an End Expiratory Flow Rate termination that is 25 - 50%, not greater than 75% of peak

expiratory flow. T_{Low} generally remains unchanged once set. For obstructed lung disease may need to set as high as 0.8 - 1.5 seconds
Tube Compensation should be activated in APRV - Set TC/ATC at 100% with proper tube size. If peak airway pressure increases try decreasing tube comp % to minimize pressure.

Neonatal

Newly Intubated patients:

P_{High} set at desired plateau pressure, typically 18-20cmH_2O
P_{Low} 0
T_{High} 2 - 3 sec
T_{Low} 0.2 - 0.3 sec, Set to achieve an expiratory flow rate termination that is 25 - 50%, not greater than 75% of peak expiratory flow. T_{Low} generally remains unchanged once set

Transition from pressure ventilation

P_{High} 2 – 3cmH_20 above MAP
P_{Low} 0
T_{High} 2 – 3 sec
T_{Low} 0.2 – 0.3 sec, Set to achieve an expiratory flow rate termination that is 25 - 50%, not greater than 75%. T_{Low} generally remains unchanged once set.

Transition from HFOV ventilation

P_{High} 0 - 2cmH_2O above mPaw
P_{Low} 0
T_{High} 2 - 3 sec
T_{Low} 0.2 - 0.3 sec, Set to achieve an expiratory flow rate termination that is 25 - 50%, not greater than 75%. T_{Low} generally remains unchanged once set.

Pediatric

Newly Intubated

P_{High} set at desired plateau pressure, typically 20-25cmH_2O
P_{Low} 0
T_{High} 2 - 5 sec
T_{Low} 0.2 - 0.8 sec, Set to achieve an expiratory flow rate termination that is 25 - 50%, not greater than 75%. T_{Low} generally remains unchanged once set.

Transition from volume/pressure ventilation

P_{High} set at plateau pressure from volume, 2 – 3cmH_20 above MAP from pressure ventilation
P_{Low} 0
T_{High} 2 – 5 sec

T_{Low} 0.2 – 0.8 sec, Set to achieve an expiratory flow rate termination that is 25 - 50%, not greater than 75%. T_{Low} generally remains unchanged once set.

Transition from HFOV ventilation Pediatric

P_{High} 2 - 4cmH_2O above mPaw
P_{Low} 0
T_{High} 2 - 5 sec
T_{Low} 0.2 - 0.8 sec, Set to achieve an expiratory flow rate termination that is 25 - 50%, not greater than 75%. T_{Low} generally remains unchanged once set.

Tube Compensation should be activated in APRV - Set TC/ATC at 100% with proper tube size. If peak airway pressure increases try decreasing tube comp % to minimize airway pressure.

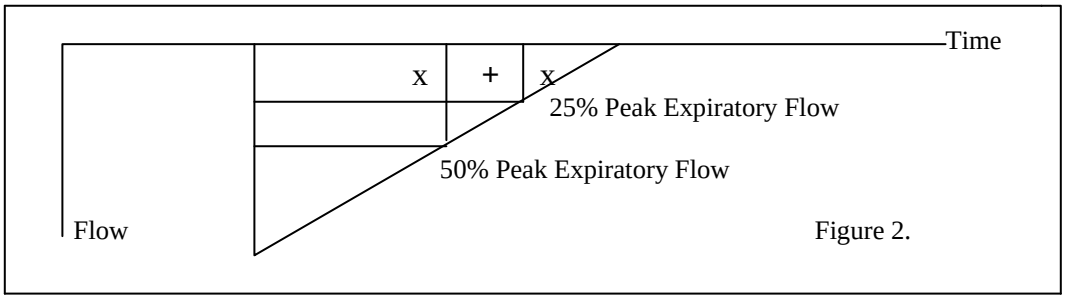

Figure 2.

NOTE: T High and T Low is the typical cycle time, and with a lack of spontaneously breathing, this cycle time will be the respiratory rate. This mode is designed to have the patient breath spontaneously. Monitoring of the minute volume and spontaneous breathing is required!

VI. Monitoring

- ***SpO2 greater than 93% or per physician order***
- Release tidal volume at least 5ml/Kg.
- Minute Ventilation may be 30-50% below conventional ventilation
- RR less than 25
- Hemodynamics (per hospital guidelines)
- Mean Airway Pressure
- EtCO2
- ABG's 20 minutes after initial stabilization and PRN.
- **If there is a significant change in the spontaneous breathing pattern, a reassessment of the effectiveness of APRV is required**.

VII. Observation of Patient

- During P high the patient should show abdominal accessory expiratory muscle excursion with expiratory flow appearing in the graphics, at the same time inspiratory efforts should be minimal as inspiration will be supplemented by the return to CPAP level. If the patient has active inspiratory activity P high

may need to be increased as the patient is still struggling to achieve good lung volume.

- During the release time watch for the patient to be actively exhaling. If this is observed the patient is struggling to get down to FRC. Either decrease the P high or increase the T low so the patient can reestablish their FRC.

VIII. Adjustments

Increasing P_{High} Pressure High is increased to maximize oxygenation and ventilation

- Increase P_H by increments of 1- 2cmH2O
- An increase of pressure high may result in the following;
  - Increased mean airway pressure, oxygenation will improve as mean airway pressure is increased and alveolar recruitement is achieved up to a point of alveolar overdistention. To achieve lung protective ventilation, plateau pressures should be at levels less than 35cmH20. Pressure greater than 35cmH2O may need to be used in patients with severe restrictive disease, decreased compliance etc.
  - Increases alveolar recruitment
  - Increases release volume
  - Increases minute ventilation
  - May be associated with decreased spontaneous tidal volume if lung reaches over distention. May also be associated with increase spontaneous volumes as lung reaches a more compliant stage.

Decreasing P_{High} Pressure High is decreased as patients compliance increases

- Decrease P_H by increments of 1 - 2cmH2O
- A decrease of P_H may result in the following;
  - Decrease mean airway pressure
  - Decrease alveolar recruitment
  - Decrease release volume
  - Decrease minute ventilation
  - Increase in spontaneous volumes

Increasing P_{Low}

- Pressure Low is generally not changed
- P_L is set at zero to allow for unimpeded exhalation
- If necessary Increase P_L by increments of 1 - 2cmH2O
- An increase in P_L may result in the following
- An increase in pressure low should be followed by the same increase in pressure of pressure high, otherwise the total ventilating pressure is decreased
  - Increase CO2 retention
  - Decrease release volume
  - Increase mean airway pressure
  - Decrease minute ventilation

- Increase resistance to exhalation

Decreasing P_{Low}

- Decrease P_L by 1 – 2cmH2O
- A decrease in P_L may result in the following
  - Decrease CO2 retention
  - Increase release volumes
  - Decrease mean airway pressure
  - Decrease resistance to exhalation

Increasing T_{High}

- Time High is increased to eliminate CO2 and to maximize recruitment
- Increasing Time High, giving fewer release rates should be the first step for CO2 elimination
- Increase T_{High} by 0.5- 1.0 seconds
- An increase in T_H may result in the following;
  - Increase mean airway pressure
  - Increase release volume
  - Increase time for spontaneous breathing
  - Increase length of actual CPAP time
  - Increase CO2 elimination (increases time for CO2 to collect in the airways)

Decreasing T_{High}

Time High may be decreased to lower release volumes and decrease mean airway pressure

- Decrease T_{High} by 0.5 – 1.0 seconds
- A decrease in T_H may result in the following;
  - Decrease mean airway pressure
  - Decrease release volume
  - Decrease time for spontaneous breathing at CPAP
  - Decrease time for CO2 elimination

Decreasing T_{Low}

Time Low may be decreased to achieve expiratory flow limitation at 25 - 75%

- T_L is set based on the expiratory flow graphics, T_L is set to limit expiratory gas flow from falling to zero thus limiting expiratory derecruitment.
- Decrease T_L by 0.2 - 0.5 seconds
- Decreasing T_L may result in the following
  - Reduce T_{Low} to terminate "Release Flow" at a higher percentage of the peak expiratory flow rate, (should be 25 - 50%, not higher than 75%). Reducing T_L may decrease release volumes causing a subsequent increase in CO2
  - Reducing T_{Low} may increase mean airway pressure
  - Once T_L is set it generally remains unchanged

Increasing T_{Low}

Time Low may be increased to achieve expiratory flow limitation at 25 - 75%

- Increase T_L by 0.2 – 0.5 seconds
- Increasing T_L may result in the following
  - Increase release volume
  - Increasing T_L will increase release volumes and may be associated with loss of end expiratory lung
  - Increase CO2 elimination
  - Decrease mean airway pressure
  - Decrease oxygenation
  - Decrease alveolar recruitment
  - To avoid complications that may be associated with auto PEEP, Time low may be extended to greater than 1 second to allow unimpeded spontaneous ventilation at pressure low. Stretching time low will increase the need to set a pressure low, thus decreasing the chances of de-recruitement. When spontaneous breathing is allowed at both levels of CPAP, the Bi-Level mode of ventilation has been reached. (see Bi-Level policy)

Weaning ***"Drop and Stretch"***

- Decrease P_{High} by 1.0 – 2.0cmH_20 or as tolerates
- Increase T_{High} by 0.5 – 1.0 second or as tolerates.
- Patient may be extubated from APRV once P_{High} of 5 - 10cmH_20 has been reached with 4 or fewer releases and patient meets extubation criteria
- Patient may be placed in a spontaneous mode with ATC/TC or pressure support prior to extubation
- **Closely monitor the mean airway pressure during this process so as not to de-recruit the lung**

IX. Equipment

A mechanical ventilator with an active exhalation valve and airway pressure release mode, which is required to allow spontaneous breathing at the two cpap levels. The two ventilators available at Boston Medical Center for APRV are the PB 840 and the Drager Evita XL ventilators. **Follow the instruction manual for the use of APRV**.

- Maintain a closed ventilator system to prevent any derecruitment as a result of a loss of pressure. Closed suction systems are recommended to minimize disconnection for pressure loss and exposure to outside environment.

X. Hazards/ Complications

- ***Hemodynamic compromise, hypotension***
- Hyperinflation
- Elevated PaCO2

- **Increased airway resistance**
- Hypo/hyperventilation

XI. Transport on APRV

Consider transporting on APRV if the patient meets any one of the following criteria

- Mean airway pressure $\geq$ 25cmH_20 unable to tolerate pressure control ventilation on transport ventilator or manual ventilation.
- FiO2 $\geq$80% unable to tolerate pressure control ventilation or manual ventilation.
- Unstable hemodynamic status.
- Unable to tolerate manual ventilation.
- Unable to tolerate PCV on transport ventilator.
- All patients spending any time in the prone position.

- Any patient with any one of the above criteria will be transported on the Draeger Ventilator.
- Any patient going to the OR ventilated in APRV will be accompanied by a Respiratory Therapist for the complete or partial procedure if the likelihood of sudden changes in compliance are foreseeable or if requested by an M.D.
- The Draeger Ventilator will be set up with 2 - O_2 tanks, (E cylinder) with the dual high pressure regulator.
- A manual ventilation device with appropriate mask ***Must*** be present on transport.
- The Respiratory Therapist should be responsible for monitoring of the airway and ventilator during transport.
- Because the likelihood of increased accidental extubation exists an intubation box ***Must*** be present during transport.

XII. References:

- Habashi, N. Other approaches to open –lung ventilation: Airway pressure release ventilation. Crit Care Med 2005 Vol 33, No 3 (Suppl) S228-S239.
- Putensen C, Zech S, Wrigge H, et al: Long-term effects of spontaneous breathing during ventilatory support in patients with acute lung injury. Am J Resp Crit Care Med 2001; 164:43-49.
- Wrigg H, Zerserling J Neumann P, et al: Spontaneous breathing improves lung aeration in oleic acid-induced lung injury. Anesthesiology 2003; 99:376-384.
- Tokics L, Hedenstierna G, Svensson L, et al: V/Q distribution and correlation to atelectasis in anesthetized paralyzed humans. J Appl Physiol 1996; 81:1822-1833.
- Neumann P, Golish W, Strohmeyer a, et al: Influence of different release times on spontaneous breathing pattern during airway pressure release ventilation. Intensive Care Med 2002; 28:1742-1749.
- Stock MC, Downs JB, Frolicher D. Airway pressure release ventilation Crit Care Med 1987;15:462-466.
- Calzia E, Radermacher P. Airway pressure release ventilation and biphasic positive airway pressure: a ten-year literature review. Clinical Intensive Care. 1997;8:296-301.
- Falkenhain SK, Relley TE, Gregory JS. Improvement in cardiac output during airway pressure release ventilation. Crit Care Med. 1992;20:1358-1360.