

## Cuff Deflation During HFOV

High frequency oscillatory ventilation takes advantage of unique principles of gas flow when respiratory frequencies exceed 3 Hz (180 breaths per minute). These gas flow principles enable the alveolar gas turnover at volumes below or equal to physiologic deadspace. One of these principles is called asymmetrical velocity profile. As Froese and Bryan described in their "State of the Art" article on high frequency ventilation<sup>1</sup>:

"Hazelton and Scherer<sup>2</sup> have proposed that even in a straight tube, since the velocity profile in one direction is parabolic and flat in the reverse direction, there will be net convective transport of material. This mechanism may be particularly effective at bifurcations where the inspiratory velocity profile becomes skewed with the peak velocities near the inner wall, whereas the expiratory velocity profile is usually symmetric."

The net effect of this asymmetry in flow profiles results in alveolar gas movement towards the airway opening occurring to a greater extent along the walls of the airways and the fresh gas towards the alveoli to a greater extent in the core of the airways. This creates a net cross-sectional difference in gas concentrations so that along the walls of the airways, the PCO<sub>2</sub> concentrations are theoretically higher than the gas concentrations in the center of the airways.

Partial cuff deflation during HFOV takes advantage of this principle so that when the cuff is deflated to create a leak, the CO<sub>2</sub> that is moving towards the airway opening, exits the patient at the edge of the cuff. Because HFOV is a constant flow system, the loss of gas around the cuff from the patient's airway that maintains mean airway pressure, is replaced by fresh gas that moves down the endotracheal tube. This gas movement is independent of the oscillatory activity and the mean airway pressure does not change. This effectively reduces the mechanical deadspace of the circuit by reducing the volume of the endotracheal tube. In some form, it may be considered to function as tracheal gas insufflation, however without the addition of a catheter down the endotracheal tube.

Our use of cuff leak during HFOV dates back more than seven years when clinicians, considering the physics described above, found that creating a small leak around the cuff enabled PaCO<sub>2</sub> to decrease 10-20 torr in many patients. This became a common practice when PaCO<sub>2</sub> levels were excessively high or there was a desire to lower the work of the 3100A HFOV. This technique was included in our training programs for Pediatric Intensivists learning how to manage large children with the 3100A. It became as common as preloading patients with fluid when high mean airway pressures were required. There were no randomized controlled trials to study this technique. It was just adopted based on empirical experience. Typically the cuff is deflated to create a leak that lowers mean airway pressure 3-5 cmH<sub>2</sub>O and then the bias flow is increased to return mean airway pressure to its desired level.

Because of the success with partial cuff deflation in the face of elevated PaCO<sub>2</sub>'s in pediatric patients and with reported rescues of adults with ARDS with the 3100A, the MOAT2 protocol included its use if PaCO<sub>2</sub>'s were higher than desirable. Of the 75 patients managed with HFOV, cuff deflation was used in 14 patients. Some of the patients had cuff deflation instituted for elevated PaCO<sub>2</sub>'s, while others used cuff deflation with normal PaCO<sub>2</sub>'s if the oscillator's power settings were on the higher end or close to its upper limit. No careful recording of its use or specific results was done. However, a survey of centers reported that it worked in most but not all patients. The typical reduction in PaCO<sub>2</sub> when it was effective was similar to our experience in the pediatric population and in the range of a 10-20 torr decrement is PaCO<sub>2</sub>.

#### References:

1. Froese AB, Bryan AC. State of art: high frequency ventilation. Am Rev Resp Dis 1987; 135:1363-1374
2. Hazelton FR, Scherer PA. Bronchial bifurcations and respiratory mass transport. Science 1980; 208:69-71