MECHANICAL VENTILATION IN SMALL ANIMAL PATIENTS: COMMON PROBLEMS AND SOLUTIONS
Carolyn L. Kerr, DVM, DVSc, PhD, DACVA
Ontario Veterinary College, Guelph, Ontario, Canada

Key Points:
1. Following institution of mechanical ventilatory support, complications can arise from either the side effects of the ventilatory support or secondary to technical difficulties occurring in the delivery of the ventilatory support.
2. The most common adverse side effects related to delivery of mechanical ventilatory support to a patient are hemodynamic depression and ventilatory associated lung injury.
3. Patient-ventilator asynchrony, loss of volume or pressure (leaks) in the anesthetic breathing circuit/ventilator, and development of excessive pressure within the breathing circuit/ventilator are the most frequent technical difficulties encountered during the provision of mechanical ventilatory support.

While providing ventilatory support can improve alveolar ventilation, oxygenation and the consistency in delivery of inhalant anesthetics, the institution of positive pressure ventilation has profound effects on the cardiovascular system. The increase in intrathoracic pressure during inspiration most notably reduces right ventricular preload and increases left ventricular afterload. In some patients, positive pressure ventilation can result in a significant decrease in cardiac output, systemic arterial pressure and overall oxygen delivery. The magnitude of these changes is dependent on the ventilatory strategy used and the patient’s hemodynamic status. Ventilatory strategies that result in high mean airway pressures, utilize long inspiratory times and/or incorporate positive end expiratory pressure tend to have the greatest negative impact on a patient’s cardiac output and systemic arterial pressures. Patients that are volume depleted or have poor ventricular contractility are most likely to suffer from the effects of a given ventilatory strategy. Strategies that utilize a low tidal volume and have a long expiratory pause are therefore appropriate when a patient with a compromised cardiovascular status requires ventilatory support. Monitoring a patient’s blood pressure and depth of anesthesia are crucial when instituting ventilatory support as profound hemodynamic changes can occur rapidly.

Healthy small animal patients are relatively resistant to primary ventilatory induced lung injury, however in a patient with lung injury, positive pressure ventilation strategies can contribute to the progression of disease. The inclusion of positive end expiratory pressure and the use of a low tidal volume strategy can minimize the progression of injury. If a prolonged period of ventilatory support is required the patient should be transferred to a critical care ventilator at the earliest opportunity to permit adjustments in the fraction of inspired oxygen and ventilatory setting based on assessment of the patient’s pulmonary mechanics and blood gas variables.

Although not a direct side effect of ventilatory support, placing a patient on a mechanical ventilator can result in faster rate of change in anesthetic depth than that experienced in a spontaneously breathing patient. Specifically, as alveolar ventilation increases, the fraction of anesthetic within the alveoli more closely reflects the anesthetic
concentration delivered to the breathing circuit. Caution must be exercised to prevent creation of an excessive anesthetic depth, particularly at the beginning of the anesthetic period when transferring a patient to inhalational based anesthesia.

Understanding how a mechanical ventilator functions is crucial as ventilator malfunctions can occur. A thorough understanding of how the ventilator functions can also minimize the risk of operator error. Ventilator-patient asynchrony, commonly referred to as ‘bucking the ventilator’, is commonly encountered during ventilatory support. It can result from many different causes including inadequate anesthetic depth, ventilatory settings that result in inadequate alveolar ventilation, hypoxemia or hyperthermia. Immediate assessment of anesthetic depth, end-tidal or arterial carbon dioxide levels, hemoglobin saturation or arterial oxygenation and body temperature are recommended. With a descending bellows volume delivered ventilator, a falling bellow or a bellow that inadequately fills during the expiratory phase of respiration is another frequently encountered situation. The most common sources of this latter problem include a leak in the breathing circuit or ventilator, an inadequate seal of the endotracheal tube within the trachea, a disconnection of the endotracheal tube from the breathing circuit, an inadequate fresh gas flow into the breathing circuit or ventilatory efforts by the patient. Although fortunately less common, excessive pressure can also develop within the breathing circuit due to inappropriate ventilatory settings (delivery of an excessive tidal volume), a pneumothorax or airway occlusion in the patient, an occluded relief valve within the ventilator or an occlusion of the scavenging system connected to the ventilator. Lethal airway pressures can develop within minutes. Fortunately most ventilators have circuit pressure alarms to warn the anesthetist when peak airway pressures exceed 20-30 cmH₂O. Overall, monitoring circuit pressures, the patient’s expired carbon dioxide waveform and hemoglobin saturation continuously greatly improves the safety of ventilatory support.

References: