ANIMAL EMERGENCY CENTER
at the heart of critical care

2100 W. Silver Spring Drive, Glendale, WI 53209
Phone: (414) 540-6710
Fax: (414) 540-6720
www.animalemergencycenter.com

ANIMAL EMERGENCY CENTER
MEMORANDUM

To: Referring Veterinary Hospitals
From: Rebecca Kirby, DVM
Date: May 30, 2007

Re: CE Fax Series: Ventilator Therapy

The Animal Emergency Center is proud to present you with the third of the 3 part series on Ventilator Therapy written by Dr. Andrew Linklater, one of the senior clinicians in the Emergency and Critical Care Service. Attached you will find **Part 3 – Determining Lung Function, Monitoring and Weaning**. Mechanical ventilation is frequently used in human ICUs to support the respiratory system while the body is recovering from the underlying disease. The AEC is proud to have the equipment and the staff with the knowledge and experience to provide this important critical care supportive procedure. Mechanical ventilation can be used for a matter of hours, up to weeks if the underlying disease process warrants and the owners opt for this life-sustaining support. The E/CC specialists and staff veterinarians are available to answer your questions.

New additions to our website include downloadable client information handouts on different forms of cancer in animals by Dr. Rachel Reiman (see the Oncology Specialty page) and Do Your Pets Brush their Teeth? By Dr. Dale Kressin (see the dentistry specialty page). In addition, there are many first aid tips and pictorial methods of restraint that your clients can learn from on the Pet's Health section of the website!

We welcome your feedback regarding the CE Fax series, AEC specialty services, and our website. Please do not hesitate to contact Christina Matthews, Assistant Hospital Administrator, or Kim Arndt, Referral Coordinator, with any questions, comments or concerns. They are here Monday through Friday to assist you with our services.

ANIMAL EMERGENCY CENTER
at the heart of critical care

2100 W. Silver Spring Drive, Glendale, WI 53209
Phone: (414) 540-6710
Fax: (414) 540-6720
www.animalemergencycenter.com

Ventilator Therapy
Part 3 – Determining Lung Function, Monitoring and Weaning

Andrew Linklater, DVM
Residency Trained in Emergency and Critical Care.

When a patient is on a ventilator, intensive monitoring, similar to a patient under prolonged anesthesia, is required. After the patient has stabilized on the ventilator and the underlying pathology has been improved, we implement our plan for weaning. From the beginning of therapeutic ventilation, it is our goal to get the pet home to the owners!

Determining Lung Function

There are some formulas that can assist us in determining lung function and the continued need for positive pressure ventilation (PPV). The Alveolar-arterial oxygen gradient (or A-a gradient, or P(A-a)O2) is an equation that helps estimate gas exchange without the variables of ventilation. The equation is: $P(A\text{-}a)O_2 = PAO_2 - PaO_2$. PaO_2 (the arterial oxygen tension) is measured on an arterial blood gas sample using a standard analyzer. PAO_2 (the alveolar oxygen tension) is estimated by the use of the alveolar gas equation, in its simplest form: $PAO_2 = 150 - PaCO_2/0.8$. The normal $P(A\text{-}a)O_2$ is less than or equal to 15 mmHg when the inspired concentration of oxygen (FiO_2) is 21%, the normal oxygen concentration of room air. If the A-a gradient is elevated, it is consistent with pulmonary parenchymal disease, or more specifically, V/Q mismatch (V = alveolar ventilation, Q = blood flow through the lungs).

Because the A-a gradient formula can become quite complicated, there is another, much simpler, method of assessing lung function through the PaO_2/FiO_2 ratio. This equation can be used while oxygen is being supplemented to the pet. Take for example a normal pet, where the inspired concentration of oxygen (FiO_2) is 21% (or 0.21), and the normal PaO_2 is 100 mmHg. This gives $100/0.21 = 500$, which is normal. In a disease state, we may try to increase the FiO_2, and this may help improve the ratio. The FiO_2 can be increased with flow-by, nasal, mask, hood or cage oxygen up to 40-50% depending on the method used and the oxygen flow rate. In humans, diagnostic criteria andcriteria for acute respiratory distress syndrome (ARDS) includes a PaO_2/FiO_2 ratio of less than 200. Low values are a reflection of severe V/Q mismatch.

Monitoring

Monitoring the patient on a ventilator requires 24-hour care and some experience. When monitoring any critically ill patient, we often refer to Dr. Kirby's "Rule of 20" (see table below. Careful attention to each aspect of the rule of 20 ensures that no major organ systems are overlooked when caring for a critically ill patient, regardless of the disease. All of these need to be addressed in the ventilator patient. Clearly we emphasize the oxygenation and ventilation, but monitoring a patient should include ALL aspects of the rule of 20, or serious complications can arise. Neglecting even one of these can lead to multiple complications and increased patient morbidity and mortality.

Typically, when a patient is on a ventilator, we will *continuously* monitor airway pressures, pulse-oximetry readings, end-tidal CO2, respiratory rate, electrocardiogram, tidal volumes, delivered oxygen concentration, mentation and the patient's ability to tolerate the ventilator. *Intermittent* monitoring (every 2-24 hours) usually consists of blood pressure, arterial blood gases and electrolytes, blood glucose, nasogastric tube suctioning, tracheal fluid production (with changes of the endotracheal tube and suctioning of the tube), urine production, PCV/TS/clotting times, albumin/BUN/lactate and other chemistry values, central venous pressure and chest tube drainage. A lot of **nursing care** is involved which includes physical therapy, changing the patient's position, nebulization (humidification and heat are often delivered by the ventilator) oral and eye care, care of the endotracheal tube, and addressing any bandages that need to be changed. Some pets will have tracheostomies performed during the course of their ventilation to allow us to lighten their anesthesia or sedation.

Weaning

Weaning a patient from a ventilator is also a complicated and often prolonged process met with many setbacks. In humans, 40 percent of the time spent on a ventilator is during the weaning process. The first requirement for weaning a patient is that their disease must be resolving. For example, a patient with a cervical neck injury or drug overdose, they will need to be taking spontaneous breaths. If they cannot do that, then they cannot be weaned. Another example is a patient with thoracic trauma or pneumonia, we want to see their disease resolving clinically and with x-rays. A patient should be able to maintain a PaO2 of >60 mmHg with an inspired oxygen concentration (FiO2) less than 50%. So, if they are able to maintain a PaO2 of >60 mmHg, then we can start weaning off the pressure breaths as an FiO2 of 50% can be delivered with other methods such as nasal, cage or hood oxygen.(ventilator technology allows us to change the inspired concentration of oxygen, stating with 100%, and weaning all the way down to room air, 21%). The patient should have low inspiratory airway pressures [peak inspiratory pressures and lower end expiratory pressures (PEEP)]. Their sedation and pain medications have to be weaned as well so they can ventilate more normally (with a normal tidal volume and respiratory rate). When the patient has achieved some of these goals, we can consider weaning the patient off of the ventilator.

There are several techniques that can be employed to wean a patient including decreasing the pressure that is delivered, decreasing the number of mechanically administered breaths (thus making the patient generate some breaths), increasing the negative pressure that must be generated by the patient to trigger a mechanically delivered breath, or intermittently discontinuing mechanically delivered breaths using a T-piece. Depending on the disease, once a patient is weaned from the ventilator, they may still need a few days in the hospital on oxygen supplementation until they are able to oxygenate normally. The veterinary staff of the Animal Emergency Center is here to meet the need of any of your patients that require therapeutic ventilator therapy!

Table 1.

Kirby's Rule of 20
How to keep them alive in ICU!

- **Fluid balance**
- **Albumin, Colloidal oncotic pressure**
- **Body temperature**
- **Blood glucose**
- **Level of consciousness, mentation**
- **Blood pressure**
- **Heart rate and function**
- **Renal function**
- **Electrolytes**
- **Liver function**
- **GI motility and function**
- **Oxygenation, ventilation**
- **Nutrition**
- **Drug dosages, interations**
- **Analgesics, sedation**
- **Wounds and bandages**
- **Red blood cells**
- **WBCs and immunity**
- **Nursing care, mobility**
- **Tender loving care!**