

## **Nursing Care of the Ventilator Patient**

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Effective and authoritative nursing management of a sedated and ventilated patient requires pre-requisite knowledge of four different areas:

1. Blood gas analysis
2. Basic knowledge of physiology and mechanics of mechanical ventilation
3. Understanding of physiology and ability to troubleshoot various monitoring devices such as: ECG, Blood pressure (often invasive), Capnography and Pulse Oximetry
4. Understanding of complications of ventilation including: ventilator-associated pneumonia (VAP), ventilator-induced lung injury (VILI), Barotrauma, Oxygen toxicity and cardiovascular effects of mechanical ventilation

After the critical care technician has a foundation in these four content areas, the nursing management (described in this presentation) will define the fifth crucial area of knowledge for veterinary technicians dealing with ventilator patients. Reasoning behind suggestions that these are requisite areas of knowledge for technician working with ventilated patients points to the fact that unless an ICU is extremely lucky to have a boarded critical care specialist and/or emergency veterinarian available at all times to tend to a ventilator patient, often VT's are left with the patient in the ICU and the DVM must go see incoming patients, attend to surgical anesthetic emergencies, deal with other critical patients, or float to a different department. Many times an ICU may not have more than one criticalist, meaning a resident, intern, student or other non-boarded DVM may be involved making the role of the technician all the greater.

Major nursing areas and topics to be described in this talk include: Basic overview of blood gases, basic overview of monitoring in a ventilated patient, major nursing domains such as: oral and airway care, recumbency care, catheter and tube care, etc and an overview of ventilator alarms and basic troubleshooting.

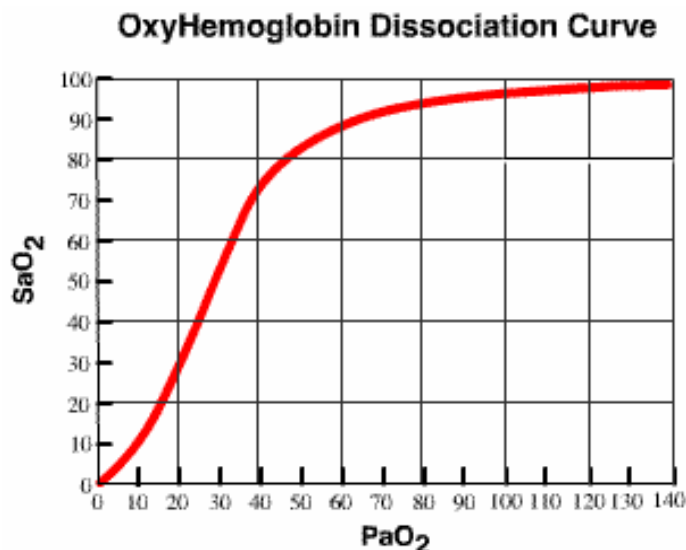
### **Blood Gases**

More important than metabolic acid-base information in the mechanically ventilated patient would be understanding the oxygenation/ventilation information provided by an arterial blood gas. Traditional blood-gas machines report a partial pressure of oxygen and carbon dioxide delineated with an "a" in the subscript if arterial. Thus, the  $P_aO_2$  and  $P_aCO_2$  are the partial pressures of dissolved oxygen and carbon dioxide in arterial blood. The carbon dioxide level is closely related to alveolar ventilation and directly corresponds to ventilatory rate or tidal volume. Hypercarbia indicates hypoventilation and hypocarbia indicates hyperventilation.  $CO_2$  can also be elevated in cases of severe lung disease (alveolar flooding). Normal  $CO_2$  is typically 35-45 mmHg.

Interpreting oxygenation indices is slightly trickier. If normal  $PaO_2$  is 80-100mmHg on room air, what should the  $PaO_2$  be when a patient is receiving 100% oxygen? 60% oxygen? The  $PaO_2$  should always be roughly 5 times the inspired oxygen content ( $FiO_2$ ). So a patient breathing 100% oxygen should have a  $PaO_2$  of 500mmHg or so. A patient on 60% oxygen should have a  $PaO_2$  of around 300mmHg. Now if one receives a blood gas report indicating sub-normal  $PaO_2$ , how do we know if it is hypoxemia and clinically significant? The  $PaO_2/FiO_2$  ratio gives a quick estimate of lung function and can be used on patients breathing  $FiO_2$ 's >21%. The traditional measure of lung function is the Alveolar-Arterial (A-a) oxygen gradient, but can only be reliably used on patients breathing 21% oxygen. If the patient's  $PaO_2/FiO_2$  is <300 (no units) then the patient can be considered at risk or demonstrating clinical signs of acute lung injury. If the patient's  $PaO_2$  is <200 the patient is at risk or showing signs of Acute Respiratory Distress Syndrome (ARDS).

The last piece of information to discuss is the relationship between saturation of oxygen at the level of hemoglobin (SO<sub>2</sub> or SaO<sub>2</sub> if arterial) and the dissolved oxygen tension (PaO<sub>2</sub>). The oxyhemoglobin dissociation curve gives us this information:

**Figure 1 Oxyhemoglobin Dissociation Curve**



**Points to consider:**

- 1- An SaO<sub>2</sub> of 98% or greater corresponds to a PaO<sub>2</sub> of 100 mmHg OR greater (flat curve)
- 2- An SaO<sub>2</sub> of 94-95% corresponds to a PaO<sub>2</sub> of 80 mmHg indicating appropriate oxygenation at room air
- 3- Patient's breathing 100% oxygen should not truly have an SaO<sub>2</sub> of less than 98%.

**Monitoring the Ventilated patient**

Monitoring devices employed in the mechanically ventilated patient include: EKG, Blood pressure (non-invasive or invasive), end-tidal Co<sub>2</sub> monitoring (capnography), temperature, and pulse oximetry. Understanding each of these is essential to properly administering effective nursing. A in-depth discussion of each of these monitoring devices is beyond the scope of this presentation. Only an overview will be presented.

- **ECG:** Electrocardiography measures electrical conduction in the heart. The heart rate reported by the ECG should always be double checked with auscultation or a manual pulse rate. Cardiac arrhythmias can certainly occur in critically ill patients and can contribute to worsening organ perfusion or cardiac arrest.
- **Capnography:** Capnography (more specifically end-tidal CO<sub>2</sub> measurement) reports the CO<sub>2</sub> in the patient's endotracheal tube at the very last part of their breath (end-tidal volume). This most closely approximates alveolar CO<sub>2</sub> and is fairly accurate. It tends to underestimate alveolar CO<sub>2</sub> so normals are about 3-5mmHg lower than arterial measurement of CO<sub>2</sub>. Mainstream and side-stream options are available. The small T-connector that is placed at the end of the patient's ET tube contributes to additional mechanical deadspace. Constant CO<sub>2</sub> measurement can be of great importance in a ventilated patient, not only indicating appropriateness of ventilator settings but also can indicate impending disaster such as barotrauma or cardiac arrest.
- **Blood pressure:** Blood pressure is the measurement of pressure within the arterial system and is affected by heart rate, stroke volume, and systemic vascular resistance. Bradycardic or tachycardic patients may be hypotensive, hypovolemic patients or patients with heart failure may be hypotensive, or patients with vasodilation or vasoconstriction may also have blood pressure abnormalities. It is a very important parameter to measure in ventilated patients as PEEP increases intrathoracic pressure and may decrease venous return and if the patient does not have pre-existing heart disease, septic and SIRS inflammatory mediators can induce cardiomyopathy, causing hypotension and decreased organ perfusion. Non-invasive

blood pressure is typically measured using Doppler technology or an oscillometric model. It is important to note that studies have validated the Doppler and invasive (arterial catheter) methods of blood pressure monitoring in the critically ill, but not oscillometric models. Arterial catheter placement has advantages in the mechanically ventilated patient in that you can measure direct arterial blood pressure and sample for arterial blood gases. The advantages of direct arterial blood pressure include: second-to-second readings, direct measurement of MAP (not calculated), and an arterial waveform.

- **Pulse Oximetry:** Discussed mainly above in the blood gas section. Pulse oximetry is a non-invasive measurement of hemoglobin and if kept normal, assumes oxygen is traversing the blood-gas barrier in the lungs. However, because only slight changes in pulse oximetry can relate to larger changes in PaO<sub>2</sub> it must be used with caution.

### Physical Exam

Ventilated patients should have regular full physical exams by a veterinarian or technician. This includes a nose-tail assessment of every major body system. Eyes and ears should be examined for any abnormalities such as ocular discharge, conjunctivitis, development of corneal ulcer, or otitis. Cotton balls in the ears should be removed, counted, and changed as needed. The oral cavity should be examined for ulcer development or glossal/hypoglossal swelling. Lymph nodes should be palpated and the front limbs massaged and rotated through full range of motion. The heart and lungs should be auscultated regularly for any crackles, wheezes, changes in heart sounds, or abnormalities in rate. The abdomen should be palpated and the genital area examined. Rear legs should be palpated for muscle atrophy and moved along their full range of motion. Finally, the tail and anogenital areas should be examined for any scald or other developments. Temperature, pulse/heart rate, pulse quality, auscultation, and mucous membrane color/CRT, blood pressure, sedation scores, end-tidal CO<sub>2</sub>, pulse oximetry, ECG, ventilator settings and laboratory results should be performed and charted at regular intervals.

### Oral/Airway Care

Development of oral ulcers, presence of regurgitation, or glossal swelling may occur in a ventilated patient. In addition, an artificial airway bypasses the normal mucociliary apparatus involved in cleaning the upper airways of debris. If an endotracheal tube cuff is not properly inflated, sedated recumbent patients may regurgitate and are at risk of aspiration pneumonia. Oral/airway care in the ventilator patient involves the following protocols: oral examination, care of the mouth/tongue, and management of endotracheal/tracheostomy artificial airways. Humidification and circuit changes will also be discussed.

#### Protocol #1: Oral examination/mouth/tongue care

- The oral cavity should be examined on a regular basis for the presence of regurgitation, development of ulcers, or swelling of the tongue
- The mouth should be rinsed or swabbed with a dilute chlorhexidine solution q4-6 hours
- Hard to reach areas, such as under the tongue or the pharynx, can be swabbed with Q-tips dipped in the chlorhexidine solution
- Tongue swelling may occur; applying a small amount of a glycerin solution will often relieve this
- The nursing staff at UC Davis developed an effective nursing intervention protocol for oral lesions which was performed every 6 hours:
  - Gently suction secretions from mouth/oropharynx
  - Lavage oropharynx with dilute chlorhexidine solution
  - Examine oral cavity; describe any lesions and their location
  - Moisten oral mucosa with glycerin
  - Wrap/pad soft tissue structures with glycerin-soaked gauze
  - Reposition ET tube, pulse oximeter, mouth gag, and tongue

*Fudge, et al. Oral Lesions Associated with Orotracheal Administered Mech. Vent. In Crit. Ill Dogs. JVECC 7 (2): 1993*

**Protocol #2: Care of an endotracheal tube**

- Endotracheal tubes are considered artificial airways, and as such need to be cared for
- They by-pass the normal defenses of the mouth, larynx and trachea
- If initial intubation was not performed with a new, sterile ET tube, the tube should be changed to a sterile one when possible
- To prevent pressure necrosis the endotracheal tube cuff should be relieved of pressure and the ET tube moved gently in or out about 1" every 4-6 hours
- Even with a humidification system instilling a small amount of normal saline through the endotracheal tube assists with moisturizing the airways and breaks down mucous as saline is mucolytic
- Mucous secretions may develop at the end or inside the endotracheal tube so suctioning is needed. After the instillation of saline a sterile suction catheter, red rubber catheter, or in-line suction catheter should be used to suction the airway
- Make sure to increase the patient's FiO<sub>2</sub> to 100% for 1 minute to increase the FRC. Then suction the airway quickly and immediately re-apply the ventilator circuit.

**Protocol #3: Care of a tracheostomy tube**

- Many patients on long term ventilation may have a tracheostomy tube placed so they can have increased function of their mouth
- The typical tracheostomy setup includes either a permanent tube settled in the trachea and an inner lumen that can be changed, or a permanent tube that must be changed ever so often
- As the patient has normal mouth function secretions build up quite often with a tracheostomy tube
- The patient should be hyper-oxygenated prior to suctioning or nebulizing their airway
- The breathing circuit can be quickly disconnected, the suctioning performed, and the circuit re-attached
- The incision site around the tracheostomy tube can be gently cleaned with sterile Q-tips and sterile saline and dilute chlorhexidine

**Protocol #4: Humidification and circuit changes**

- Circuit changes may be necessary if they become clogged or what was assumed to be best practice (in the past) to change them.
- However, frequent circuit changes is considered a risk factor for VAP and thus the CDC recommends only changing the ventilator circuit NO MORE than every 48 hours

**Recumbency/Passive Range of Motion**

Ventilator patients are recumbent and require thick bedding to prevent the development of decubital ulcers. Any pressure points (elbows, hips) can develop ulcers quickly and prevention involves thick padding and rotating the patient to disperse the pressure placed on these areas. Keeping the patient sternal is preferred and then the patient's hips may be rotated from side to side every 4 hours. Careful monitoring for any excrement is necessary to prevent scald and tissue trauma leading to secondary bacterial colonization. Passive range of motion and massage therapy can help maintain appropriate blood flow to the periphery and is important to do during "down-time" between treatments.

**Catheter/Tube Care**

Ventilator patients OFTEN have the following "tubes" that need care: Peripheral IV catheters, jugular/saphenous central lines, arterial catheters, urinary catheters, feeding tubes (NG, E-tube, PEG), and potentially chest tubes, abdominal drains. All of these should be monitored for any signs of inflammation or infection. Catheters (peripheral or central) should have catheter care performed at least every 24 hours: strip the bandage material and tape off of the catheter and inspect the site, while wearing non-sterile gloves. If there are any signs of phlebitis the

catheter may need to be removed. Urinary catheters should be cleaned with dilute chlorhexidine from the prepuce to the urinary catheter bag by wiping distally to move any bacteria/contamination away from the urinary tract. The vaginal vault or prepucial sheath should be flushed with chlorhexidine solution as well. Urinary lines (if not completely closed systems) should be changed every 24 hours.

### **Charting/Record Keeping**

Charting and record keeping is very important with ventilator patients. Flowsheets should include hourly treatments both ventilator-specific and those accompanying the primary disease process. If this is too much information, a second ventilator-specific flowsheet should be created to facilitate administering all of the appropriate medical care. Ventilator settings (tidal volume, RR, I:E ratio, PEEP levels, airway pressures, mode, FiO<sub>2</sub>) should be recorded every hour. Regular treatments: suctioning, cuff deflation, body positioning, etc can be listed on this sheet and then highlighted or marked to be performed at the appropriate intervals. Clear and legible handwriting is very important.

### **Ventilator Alarms/Troubleshooting**

Common problems in ventilator patients include: Ventilator-induced lung injury (VILI) and ventilator-associated pneumonia (VAP). Recommendations from human medicine been quite successful in implementing care bundles to identify patients at risk of VAP and institute care immediately if VAP is suspected. The care bundle is presented here:

- 1- Wash hands and do not wear rings when dealing with ventilator patients.
- 2- Elevate patient's head 30-45° when possible.
- 3- Avoid gastric overdistension
- 4- Avoid intubating and re-intubating if possible
- 5- Use of a cuffed ET tube plus in-line subglottic suctioning

A common problem with ventilator patients is ventilator-patient dysynchrony or "bucking." This is usually caused by one of two things: 1- Sedation/analgesia is not adequate and patient is "light" or 2- Ventilator settings are not adequate for patient causing distress. Re-assess the ventilator settings and the patient's sedation levels if you find the patient is reacting to the ventilator.

### **Common ventilator alarms include:**

***\*\*Make sure all alarms are set to appropriate patient settings. No sense in the low FiO<sub>2</sub> alarm going off IF the patient is supposed to be on 21% oxygen!\*\****

**Low tidal volume alarm:** This occurs when the machine senses a tidal volume breath that did not make it to the pre-set tidal volume. This can occur if there is a leak in the ventilator circuit, ET tube or cuff, or the cuff is not sealed appropriately.

**Low pressure alarm:** This occurs for similar reasons the low tidal volume alarm would go off. However, it is important to note that an early pneumothorax can trigger a low pressure alarm as there ventilator driven pressure is now "leaking" into the pleural space.

**High pressure alarm:** This may occur because there is a blockage in the ET tube or circuit, or the patient has developed a pneumothorax from barotrauma. This is a very serious alarm .

**Low FiO<sub>2</sub> alarm:** Another serious alarm sensing that the delivered oxygen concentration is not what the pre-set levels are supposed to be. This may indicate an oxygen failure, machine failure, or inadequate supply of oxygen in the hospital.

References available upon request