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Using A Mechanical Ventilator: How, When & What

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Concerning the use of intermittent positive pressure ventilation (IPPV) with the use of a mechanical means three keys points need to be considered. They are:

1. **How to set up and test the ventilator for leaks.**
2. **When is it necessary to ventilate a patient?**
3. **What do the numbers mean?**

The number one key point to using the ventilator is to make sure the anesthesia machine does not leak. If the machine leaks, then the ventilator will leak and not function properly.

Once a proper leak test has been performed on the anesthesia machine (as described in Vapors Vol. VII, Issue 3 Fall 2016), the ventilator can be connected to the anesthesia machine and the bellows, housing & hoses can be tested for leaks.

Common leaks with the ventilator are:

1. Holes in the hoses and/or air way sampling tee
2. Pin holes or rips in the bellows
3. Cracks in the housing
4. Leaky Pop-off valve within the ventilator

There are two types of bellows which are more recently described as Standing (ascending) or Hanging (descending). The description of Standing or Hanging describe the position of the bellows during the expiratory pause. The majority of modern ventilators use the Standing bellows which can be easily checked for leaks. Remove the reservoir bag from the anesthesia machine and replace it with the output tubing on the ventilator. Fill the bellows with either the flowmeter or flush valve. **Never use the flush valve when a patient is connected to the ventilator**. Once the bellows reach the top of the housing, turn off the flow of oxygen and observe the bellows. They should remain at the top of the housing and not fall if the system is free of leaks.

Now that the equipment is ready for use the next key point to consider is when should IPPV be used. There are several factors to consider when answering this question. Some of the factors to consider are respiratory rate, $EtCO_2$, tidal volume, positioning, length of the procedure and cardiopulmonary disease. There are also certain situations where ventilating the patient is necessary. Examples are thoracotomies, diaphragmatic hernias, apnea and hypercapnia. Consideration should also be given to the fact that the use of IPPV will inevitably reduce blood pressure and cardiac output in all species. This is due to during inspiration positive pressure replaces the negative pressures that develop during spontaneous respiration. This will restrict the venous return and cause blood pressure to decrease. Therefore, it is recommended to measure blood pressure either by non-invasive or invasive means prior to initiating IPPV. It is much easier to correct hypotension and then initiate IPPV than to ventilate immediately and try to correct the hypotension.

Hypercapnia is another factor to consider when ventilating a patient. There is controversy about when to ventilate based on the numbers received from capnography. Normal arterial CO_2 ($PaCO_2$) is 35-45mmHg in all species. The number received from a capnometer is $EtCO_2$ and is typically 5-10mmHg lower than $PaCO_2$. (Ex: $EtCO_2$ of 50mmHg will be a $PaCO_2$ of 55-60mmHg). The controversy lies in how high to allow $EtCO_2$ before ventilating a patient. Studies have shown benefits to a mild hypercapnia ($EtCO_2$ 50-55 mmHg) known as permissive hypercapnia. By not ventilating these patients the blood pressure and cardiac output may actually improve. Therefore, it is important to treat every patient individually and evaluate all the parameters.

The following case scenarios are examples of when and why to ventilate a patient.

Equine: 1200 lb. mare in dorsal recumbency for an ovarian tumor. Arterial catheter is placed, and hypotension is corrected with a CRI of Dobutamine. Respiratory rate is 5 bpm and $EtCO_2$ is 55 mmHg and the length of the surgery is estimated at one hour. Prolonged periods of hypercapnia can lead to myocardial depression and respiratory acidosis. Initiating IPPV at the beginning of this case would prevent these complications. IPPV will also assist in reaching a plane of surgical anesthesia quicker than spontaneous ventilation. (See side bar for recommended settings).

Canine: 80 lb. Spinone in dorsal recumbency for ruptured cruciate repair. Premedication of opioids and acepromazine and induction with Propofol. Respiratory rate (RR) of 8 bpm, $EtCO_2$ is 45 mmHg and systolic blood pressure (SBP) is 100 mmHg. Surgery time is estimated at 40 minutes. Upon surgical stimulation the patient awakes, RR increases, SBP increases more Propofol is given and the inhalant is increased to 3%. Patient's SBP reduces to 80 mmHg, RR rate is 6 bpm and the inhalant is decreased to 1.5%. Ten minutes later the patient awakens, and the same scenario is repeated. Placing this patient on a ventilator once the SBP is > 90 mmHg will stop the "roller coaster" effect of this case and allow the reduction of inhalant and help maintain a surgical plane of anesthesia.

Recommended Settings for IPPV:
Respiratory Rate (RR), Peak Inspiratory Pressure (PIP), Tidal Volume (TV)

Equine:	RR – 6-10 bpm	PIP – 20-30 cm H20	TV – 1L/100 kg (10 ml/kg)
Swine:	RR – 8-18 bpm	PIP – 15-20 cm H20	TV – 10-15 ml/kg
Ruminants:	RR – 8-12 bpm	PIP – 15-25 cm H20	TV – 13-18 ml/kg
Canine:	RR – 8-12 bpm	PIP – 10-20 cm H20	TV – 10-15 ml/kg
Feline:	RR – 10-14 bpm	PIP – 10-20 cm H20	TV – 10-15 ml/kg

It is impossible to address all the specifics in this article for when to ventilate your patients. Please realize these are only guidelines and the specific settings should be determined by the individual patients and their specific needs.

Meet Our Team

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Debbie Coleman graduated from the Animal Health Technology program in 1980 from Truman State in Kirksville, Missouri. She worked in a two-man mixed animal practice in Paris, Missouri for 8 years. In the fall of 1987, Debbie joined the anesthesia staff at the Iowa State Veterinary Teaching Hospital and worked as an anesthesia technician until March of 2008.

Debbie is currently a senior field service technican/sales associate for Vetamac. She repairs and maintains anesthesia machines for veterinarians in Iowa and the surrounding states.

Debbie is a member of NAVTA, VECCS, and a charter member of the Academy of Veterinary Technician Anesthetists where she served as President from 2005-2006. She has provided lectures to national meetings including WVC, NAVC, ACVIM, AVMA, and SWVC.

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