Anesthetic machines play a key role in keeping a patient anesthetized. They deliver oxygen and anesthetic gas to the patient as well as filter out harmful expiratory carbon dioxide. It is imperative to understand the anesthetic machine and its breathing systems to safely and effectively anesthetize the patient while keeping environmental pollutants to a minimum.

**Basic Anesthetic Machine Components**

**Compressed Gases**
- Oxygen, Nitrous Oxide, etc.
- Color coded.
- Gases/liquid under high pressure.
- Attached to the anesthetic machine with a hanger yoke or a high pressure hose.
- **Used as carrier gases for the inhaled anesthetics.**

**Pressure Regulator**
- **Reduces the high pressure** of the incoming gas to a lower pressure.
- Allows the anesthetic machine to operate at a lower pressure making it safer and easier to use for the patient and anesthetist.
- **Indicates amount of gas contained in cylinder.**

**Flowmeter**
- **Controls the rate** that a carrier gas is delivered. (ml/min; L/min)
- Gas specific.

**Anesthetic Vaporizers**
- Isoflurane, Sevoflurane, etc.
- **Volatilizes the liquid anesthetic to a gas anesthetic.**
- Used to deliver a precise concentration of a specific inhaled anesthetic.
- Vaporizers can be located out of the circle circuit (VOC) or in the circle circuit (VIC)

**Oxygen Flush Valves**
- **Delivers fresh oxygen** to the common gas outlet **bypassing the vaporizer.**
- **Used for pressure testing the system and flushing the system of anesthetic.**

**Carbon dioxide absorbent canister**
- Chemically **removes carbon dioxide from the patient’s exhaled air.**
- **Medium needs changed every 6 to 8 hours of use.**
- Absorbent **turns blue or violet as the medium is exhausted.** (This color change will revert back to normal if the absorbent is rested.)
Pressure relief (pop-off) valves
- Allows the escape of excess pressure in the system.
- Valves can be closed to manually breathe for the patient or to pressure test the system.

Scavenging systems
- Collects the anesthesia machines waste gasses and disposes of them properly.
- Passive scavenging systems use a canister of activated charcoal to nullify the harmful gases.
- Active scavenging systems use a vacuum or other device to draw the waste gases to the outside.

Reservoir bag
- Collects oxygen and anesthetic gas before it is delivered to the patient.
- Can be used to manually breathe for the patient.
- Prevents immediate pressure build up if the pop-off valve is left closed.
- Available in different sizes dependent of the patient's tidal volume.

Rebreathing tubes
- Connects the anesthetic machine to the patient.
- Pediatric circle circuits are for patients less than 5kg.
- Adult circle circuits are for patients over 5kgs.
- Universal-F is a type of circle circuit where the inspiratory tube runs inside the expiratory tube. The expiratory tube warms the inspiratory air aiding in patient warming and humidification.

Pressure manometer
- Indicates the amount of positive pressure in the anesthetic system.
- Unit of measurement is cm of H₂O.

Breathing Systems

Breathing systems rely on the patient's natural ability to breathe in order to function.

The wide range of sizes and tidal volumes for small animals make it impossible to have one system that will work for all patients. The two most common breathing systems for small animals are rebreathing and non-rebreathing.

Rebreathers (Circle systems)
- Remove carbon dioxide from exhaled gases by routing them through a chemical absorbent. After the carbon dioxide is removed, the expired gases are mixed with the fresh incoming gas and oxygen to be inhaled by the patient.
- Reusing the expired gasses conserve oxygen and anesthetic making rebreathing systems economical.
- Rebreathers also retain heat and moisture promoting patient warmth during the procedure. The downside to rebreathing systems is the machine is bulky and complicated.
- High resistance to ventilation making it difficult for smaller animals with a low tidal volume to move the gasses in this system effectively.

Non-rebreathers (Bain systems)
- Do not reuse the expired gasses and rely on a high gas flow to flush carbon dioxide into the scavenger system.
• This system is simple to use, lightweight, and has a low resistance to ventilation making it appropriate for small patients with a low tidal volume.
• The disadvantage to this system is the higher gas flow promotes hypothermia.
• High consumption of gases makes it expensive to use.

Trouble Shooting

• Trouble shooting the anesthetic machine and breathing system is one of the most important jobs of the anesthetist. Being able to prevent, identify, and resolve problems could save lives.
• Most problems can be found and before the patient becomes involved with a thorough pre-procedure check.
  • Some things to look for are expired carbon dioxide absorbent, empty vaporizer, and a disconnected scavenger system.
• A common problem with anesthetic machines is leaks. Leaks can be found with a simple pressure test of the system and frequently occur where the circle tube and reservoir bags are attached. Breathing tubes and bags are frequently changed leading to stress cracks and holes at their connection points. The smell of anesthetic gas during a procedure indicates a leak in the system.
• Some problems with anesthetic machines don’t arise until a patient is attached. One way valves can become stuck closed from condensation from the patient’s expiratory breath. This could cause the patient to breathe unfiltered expired gases. Vaporizer calibration can also be a problem. The patient may become deeply anesthetized or will have a hard time staying anesthetized if the vaporizer calibration is off.
• After a procedure the anesthetic machine should be visually inspected and cleaned properly. Breathing tubes and reservoir bags should be washed and hung to dry. One way valves should be opened, cleaned, dried, and replaced. Taking proper care of your anesthetic machine and breathing systems will make them last longer, work more effectively, and be safer for the patient and anesthetist.

Pressure Test

A pressure test of an anesthetic machine and breathing system ensures that there are no leaks and that the pop-off valve is working properly. This is performed by:

• Closing the pop-off valve and occluding the patient end of the breathing circuit.
• The system is then pressurized to 30 cm H₂O and the flow meter set at 200 ml/min. The machine is considered leak free if the pressure on the manometer holds or slowly increases, but if it drops, you have a leak greater than 200 ml/min and it should be found.
• Some ways to find where the system is leaking is to listen or feel for it.
• Leaks can also be found with a surfactant solution. The solution is sprayed on the machine anywhere a leak is suspected and will bubble if one is present.
• Once the machine is leak free the pop-off should be opened to let the pressurized air out of the system. This ensures that the pop-off isn’t stuck closed and is working correctly.
References