

PATIENT MONITORING EQUIPMENT

An Important Note on Monitoring Devices:

Monitoring equipment can provide valuable information and act as an extension of the anesthetist's own senses. However, machines can malfunction or fail. The anesthetist should not rely solely on equipment and should physically check the patient at frequent intervals to confirm that the readings are accurate. Many monitoring devices average signals over a period of time to obtain a reportable reading, resulting in a delayed response to changes in patient status. In addition, some changes, such as cyanosis and pallor cannot be assessed by a machine. THE most important monitoring technique is clinical assessment by the anesthetist's own senses.

Esophageal stethoscope

- Consists of a thin, flexible tube attached to a regular stethoscope.
- The tube is inserted through the patient's mouth into the esophagus and advanced until an audible heartbeat is detected through the ear pieces. Placement after the animal has been intubated avoids the possibility of the stethoscope accidentally entering the trachea.
- Allows auscultation of heart and lung sounds even if the patient is covered by surgical drapes.

Pulse oximeter (SpO₂)

- Shines red and infrared light, via a clip-like probe, through a thin piece of tissue such as the tongue and measures the relative absorption of the two wavelengths.
- Oxygen saturation (ratio of oxyhemoglobin to deoxyhemoglobin) is calculated from programmed absorption curves and reported as the proportion of hemoglobin which is oxygenated.
- Measures adequacy of arterial oxygenation, but not a measure of ventilation or oxygen delivery.
- The absolute accuracy of pulse oximeters seems to be lower for animals than humans, but the trends are still important. In general a saturation of >95% is good. If it falls to 92-94% you should take note but corrective action may not be necessary, especially if the cause is known and self-limiting. When the saturation falls below 92% action must be taken to improve oxygenation.
- If pulse oximeter readings are abnormally low during anesthesia, consider the following:
 - Is adequate oxygen being delivered to the patient? Inadequate oxygen delivery may result from esophageal intubation, endotracheal tube blockage or equipment problem.
 - Is oxygen being transferred from the alveoli to the blood? This process may be impeded by inadequate ventilation or preexisting lung disease.
 - Is circulation adequate? Bradycardia, severe arrhythmias, or hypotension may decrease oxygenation. Impaired peripheral perfusion (low cardiac output, vasoconstriction, hypothermia) may interfere with readings (and indicate issues that need to be addressed).
 - Is the instrument working correctly? Readings may be affected by factors such as probe placement, external light sources and motion.
- Addressing problems with the pulse oximeter:
 - Assess your patient!
 - **Do not assume that an abnormal reading is the result of equipment failure** until you have assessed all parameters and determined them to be normal.
 - Readjust the probe. Especially in cats and other smaller patients, the probe may occlude the blood supply to the area where the clip is placed. Moving the probe to a different location on the tongue may help. Alternatively, the ear pinna or toe web can be tried.
 - Wet the tongue. The probe needs moisture to work properly. If the patient's tongue is dry, remove the probe and wet the area with a few drops of water.
 - Check the battery. If the low battery light and/or alarm is signaled, request a new battery.
 - If all else fails-restart the machine: If you are certain that your patient is not having a problem, try turning the machine off for a few moments then replacing and trying again.
 - If you continue to have a problem with the machine. Resume your monitoring of other parameters and ask for assistance.

Blood Pressure

- Arterial blood pressure consists of three values:
 - Systolic pressure: The pressure generated by ventricular contraction. This is the highest pressure exerted throughout the cardiac cycle and can be felt as the arterial pulse.
 - Diastolic pressure: The pressure that remains when the heart is in its resting phase, between contractions. The lowest pressure that is exerted throughout the cardiac cycle.
 - Mean arterial pressure (MAP): The average pressure measured over one complete cardiac cycle. Calculated as $1/3$ the systolic pressure plus $2/3$ the diastolic pressure.
- Blood pressure is measured indirectly using either an oscillometric device or a Doppler ultrasound flow detector. Both instruments have advantages and disadvantages. As indirect measurements can be significantly different from direct measurements, results should always be interpreted with caution. Again, trends may be more important than actual readings.
- All patients anesthetized at HSVMA-RAVS' clinics are monitored using oscillometric monitors. These measurements are generally very accurate in large and medium-sized dogs and most cats. They can be less accurate in very small animals and hypotensive patients. A Doppler monitor is available if needed to verify measurements or obtain readings on smaller animals.
- To use the oscillometric monitor: An appropriately sized cuff is placed over any accessible artery, generally around a limb distal to the elbow or hock with the inflation tubing running in the direction of arterial flow (away from the body).
- The cuff should be approximately 40% the circumference of the limb around which it is placed. Too large a cuff can give artificially low readings; too small will show falsely elevated readings.
- It may be necessary to loosely tape the cuff to prevent the velcro from opening when inflated.
- Oscillometric devices work by detecting pressure oscillations within the bladder of the cuff placed over an artery. The cuff is connected via a pressure cable to the monitor. The monitor inflates the cuff until flow is occluded and then slowly deflates the cuff. As the pulse returns the systolic, diastolic and mean arterial blood pressures are reported. Poor pulse signals from poor flow, small arteries, movement or shivering will interfere with accuracy of these devices.
- Normal systolic pressure in the dog and cat is approx 120 mmHg (range 80-140); normal diastolic pressure is 80 mmHg (60-100)-together indicated as 120/80. Normal MAP: 70-90 mmHg
- Systolic pressure in the anesthetized patient should be maintained above 80 mmHg, with MAP maintained above 60 mmHg. Below these levels, organ function may be compromised.

Electrocardiogram (ECG or EKG)

- Although we will not be using the ECG on most patients, it is available when needed and you should have a basic knowledge of its use.
- The ECG monitors the electrical activity of the heart. With each beat the atria and ventricles depolarize and repolarize. The depolarization and repolarization are synchronized in each chamber and thus the action potentials from each fiber summate, producing a signal that is large enough to be measured at the surface of the body. The electrical signal is picked up by electrodes, amplified and displayed on a screen.
- The ECG is always measured as the difference in voltage between two electrodes. Depending upon the placement of the electrodes the ECG has different shapes. If the electrodes are placed on each arm a lead I waveform is obtained. Lead II is measured from the right arm to the left leg, and lead III is measured from the left arm to the left leg.
- For anesthetic monitoring, a lead II trace, with positive P, R and T wave is usually chosen.
- The typical ECG lead arrangement for anesthetic monitoring has leads placed on the left (black connector) and right (white connector) arms and left leg (red connector). It is often easier to place the arm electrodes on either side of the chest rather than on the arms. The leg electrode can go on the inside of the thigh where the hair is thin.
- The electrocardiogram monitors only the electrical activity of the heart. It will tell you nothing about the mechanical function of the heart or the state of the circulation. As such, electrocardiograms are not generally the first choice for anesthetic cardiovascular monitoring.