

MONITORING THE ANESTHETIZED PATIENT

The administration and monitoring of anesthesia for surgical procedures is a complex and multifaceted skill that requires both knowledge and practice. The safety of your patient is dependent on your awareness and response to potential problems. A thorough understanding of the principles of anesthetic monitoring and awareness of normal and abnormal patient parameters is crucial to providing safe anesthesia. The most important thing to remember is to ASK QUESTIONS-anytime you have a question or concern about a patient's status. Don't ever hesitate to ask for help.

It is the anesthetist's sole responsibility to monitor the safety of his/her patient at all times. An anesthetized animal should NEVER be left unattended for any reason. Monitoring of the anesthetized patient is a continual process throughout the anesthetic event from pre-medication to full recovery. Vital signs and other monitoring parameters are recorded to the surgery record every 5 minutes throughout the procedure, but patient monitoring should be continuous. The anesthetist should be aware of subtle changes in parameters and prepared to address any issues immediately as they arise.

Remember when assessing the anesthetized patient that, while absolute numbers are obviously important, subtle change and trends are often an early indicator that the patient is beginning to decompensate. Do not wait until a patient's monitoring parameters are in the critical range to act or to ask for assistance.

These training materials are intended as a basic review of these important topics. For more information please refer to one of the numerous texts available. As you review these materials, keep in mind that anesthesia and surgery are clinical skills, not just academic pursuits. You are going to be DOING these things, not just passing an exam. If you have questions about any of this information you are welcome to contact us prior to your trip.

PARAMETERS TO BE ASSESSED CONTINUOUSLY THROUGHOUT ANESTHETIC PERIOD (RECORDED EVERY 5 MINUTES):

Respiratory

- Airway
- Respiratory rate, depth and character
- Oxygen saturation (SpO₂)

Cardiovascular

- Heart rate and rhythm
- Pulse rate and strength
- Mucous membrane color and capillary refill time
- Arterial blood pressure

Body Temperature

Anesthetic depth/patient status

- Reflexes and muscle tone
- Eye position and pupillary reflex activity
- Heart and respiratory rates
- Status of surgical procedure

Equipment function

- Anesthetic level,
- Vaporizer and oxygen flowmeter settings
- Pressure relief (pop-off) valve

ASSESSING MONITORING PARAMETERS

Respiratory

➤ Airway

- Check regularly that the endotracheal tube has not kinked, slipped out or been placed too deeply. Listen for accumulation of moisture in the endotracheal tube.
- In recovery, animals should be placed with the neck extended so the ET tube is not bent or kinked. Recovering animals should be placed facing forward in their cages with the tongue protruding to allow easy visualization of the animal's mucous membrane color.

➤ Respiratory rate (RR), depth and character

- **Normal RR: 10-20 breaths/minute** (rates up to 40 may be seen occasionally)
- Normal inspiration lasts 1-1.5 seconds and expiration lasts 2-3 seconds
- Basic respiratory monitoring is based on clinical observations. The rate and depth can be assessed by observing movement of the chest or reservoir bag. Chest excursions should be assessed with both spontaneous respiration and assisted ventilation. Respiratory rate and character can be evaluated via esophageal stethoscope.
- The degree of compliance felt when manually ventilating the animal can provide important information about potential respiratory or mechanical dysfunction.
- With increasing depth of anesthesia there is a decrease in both the rate and tidal volume (volume of air taken in with each breath). When the animal hypoventilates, some alveoli may not adequately inflate. These alveoli partially collapse, leading to atelectasis. Periodic 'bagging' (every 5 minutes) throughout the procedure can prevent this.
- To bag a patient, partially close pop-off valve and gently squeeze the reservoir bag just enough to cause a slight rise in the chest. Be sure to re-open the pop-off valve to avoid the buildup of pressure in the anesthetic circuit.
- An abnormally low respiratory rate (<8-10 bpm) is cause for concern and should be reported to a supervising veterinarian or technician immediately. Apneic animals who are otherwise maintained at an appropriate anesthetic level may need to be manually ventilated throughout the procedure at a rate of 8-12 bpm.
- The anesthetist may occasionally note an increase in respiratory rate (tachypnea) and depth (hyperventilation). True hyperventilation and tachypnea (as opposed to panting) are the body's response to increased carbon dioxide in the blood or metabolic acidosis.
- Hyperventilation may indicate that the CO₂ is not being adequately removed from the breathing circuit by the CO₂ absorber. Hyperventilation is also seen as a response to mild surgical stimulus (e.g. when surgeon pulls on suspensory ligament during OVH).
- An elevated respiratory rate may indicate a progression from moderate to light anesthesia and is often one of the first signs of arousal from anesthesia.
- Breathing should be smooth and regular, with thoracic and diaphragmatic components. Difficult or labored breathing may indicate the presence of an airway obstruction.
- Animals anesthetized with ketamine may exhibit an apneustic respiratory pattern, in which inspiration is followed by a prolonged pause before expiration.
- Normal respiratory sounds are almost inaudible. Harsh noises, whistles or squeaks may indicate narrow or obstructed airways or the presence of fluid in the airways.

➤ Oxygen saturation (SpO₂) - (see 'Monitoring Equipment' for more information)

- **Normal SpO₂ : 95-100%**
- The patient's SpO₂ is the percentage of oxygen-saturated hemoglobin, and indicates how well the lungs are delivering oxygen to the blood.
- The pulse oximeter measures both SpO₂ and heart rate and is monitored continuously.

- A pulse ox reading of 90-95% indicates that the patient's hemoglobin is not fully saturated and a respiratory or cardiovascular problem may be present. The patient will not become hypoxic until the reading falls to 90% or less. It is hoped that the anesthetist will be able to correct the problem before this occurs. Without pulse oximetry, early hypoxia can be difficult to assess as cyanosis only becomes apparent if values fall below 85% saturation.
- As with any monitoring device, the pulse oximeter can sometimes fail or provide an inaccurate reading. Anytime the reading changes significantly, evaluate the clinical status of your patient before assuming that the reading is accurate.
- However, do not assume that a low reading is a malfunction. Again, **EVALUATE YOUR PATIENT** before making any decisions.

Cardiovascular

➤ Heart rate (HR) and rhythm

- **Normal HR: Canine: 80-120 bpm; Feline: 100-180 bpm**
- Assess via auscultation.
- Bradycardia may indicate excessive anesthetic depth, a response to vagal stimulation or other causes. Heart rates less than 80 bpm in dogs and 100 bpm in cats should be reported to a supervising veterinarian or technician for evaluation.
- Tachycardia may be a response to surgical stimulation and, in combination with other factors may indicate an inadequate anesthetic level. However, some response to surgical stimulation is normal.
- The presence of a beating heart does not necessarily mean that circulation is adequate. Heartbeat should always be assessed in conjunction with pulse strength and quality.

➤ Pulse rate and strength/quality

- The pulse can be detected at several locations, including the lingual, femoral, carotid and dorsal pedal arteries. You should know a least 3 different places to evaluate a pulse.
- The pulse should be strong and synchronized with the heartbeat.

➤ Mucous membrane (MM) color and capillary refill time (CRT)

- **Normal: mm pink, CRT < 2 sec**
- Mucous membrane color is usually most easily assessed at the gingiva. Pale mucous membranes may indicate blood loss or anemia or may result from poor perfusion. Purple or blue mucous membranes indicate cyanosis, a shortage of oxygen in the tissues. Cyanosis during anesthesia is usually the result of respiratory failure or upper airway obstruction and must be addressed immediately.
- Capillary refill time is the rate of color return to a mucous membrane after the application of gentle pressure and reflects tissue perfusion. Pressure on the mucous membranes compressed the small capillaries and blocks blood flow to that area. When the pressure is released, the capillaries rapidly refill with blood and the color returns, provided the heart is able to generate sufficient blood pressure.
- However, a short CRT is not an infallible indication that circulation is adequate.
- A prolonged CRT (> 2 sec) may indicate hypotension resulting from excessive anesthetic depth or circulatory shock. CRT is usually prolonged in patients in whom the systolic blood pressure is less than 80 mm Hg. Animals suffering from this degree of hypotension will usually feel cold and have pale mucous membranes.
- Other factors that may cause prolonged CRT or poor perfusion include hypothermia, vasodilation and cardiac failure.

- **Arterial Blood Pressure** (*see 'Monitoring Equipment' for more information*)
 - **Normal BP: 120/80 mm Hg (80-120 mmHg systolic, 60-100 mmHg diastolic). Normal Mean Arterial Pressure between 70-90 mmHg**
 - Measurement of arterial blood pressure provides information regarding the adequacy of blood flow to the patient's tissue.
 - Arterial blood pressure may be monitored using various methods such as a Doppler ultrasound probe coupled with a pressure cuff and sphygmomanometer or an automated oscillometric device (e.g., Dinamap), which are most commonly used in RAVS clinics.
 - The disadvantage of oscillometric detector is decreased accuracy and efficiency when used on hypotensive or small patients (less than 5 kg body weight).
 - The minimum acceptable BP is 80/40. If the mean arterial blood pressure (MAP) is below 60 mmHg, organ and tissue perfusion is inadequate.
 - The most common cause of hypotension is excessive anesthetic depth. Other causes include hypovolemia due to intra-operative bleeding or pre-operative dehydration, hypothermia or hypoxia.

Body Temperature

- Anesthesia will typically lower the body temperature and can lead to hypothermia, which can result in prolonged recovery from anesthesia as well as other complications. Small puppies and kittens are especially vulnerable.
- The greatest loss in body heat occurs within the first 20 minutes of anesthesia.
- Cold surfaces and excessive use of cold scrub solutions should be avoided. During surgery, 'Snuggle Safe' warming disks should be placed under a towel between the patient and surgery table to help the animal conserve body heat. Animals in recovery can be placed on a covered heating pad and covered with a blanket until the body temperature is normalized.
- Care should always be taken with any supplemental heat source to avoid burns or hyperthermia. Heating pads should ALWAYS be set at the LOW setting. Warming devices and hot water bottles should be wrapped in a towel or other barrier. Body temperature should be monitored frequently and supplemental heat should be discontinued when the patient's temperature is 99-100°F.

Anesthetic Depth/Patient Status - (*For more information see 'Assessing Anesthetic Depth'*)

During the course of anesthesia, the anesthetist should monitor as many parameters as possible and weigh all available evidence before judging the anesthetic depth of the patient. No one piece of information is unfailingly reliable and each animal has a unique individual response to any given anesthetic protocol.

Although anesthetic stages and planes may appear easy to differentiate on paper, they are not well defined in every animal. The anesthetist must assess as many parameters as possible to come to a conclusion regarding the patient's depth of anesthesia. The basic rule is that if there is any doubt about the level of anesthesia, one should decrease the vaporizer setting and monitor the animal until the anesthetic depth can be determined.

Classic Stages of Anesthesia

- Stage I - Not anesthetized
- Stage II - Excitatory phase, not anesthetized
- Stage III
 - Plane 1 - light anesthesia
 - Plane 2 - moderate anesthesia (surgical plane)
 - Plane 3 - deep anesthesia
- Stage IV - Overdose
- Stage V - Death

➤ **Reflexes**

- Normal, conscious animals demonstrate predictable protective reflex responses to certain stimuli. These protective reflexes are progressively depressed at increasing depths of anesthesia. Progressive return of reflexes indicates imminent arousal from anesthesia.
- **Palpebral** (blink) - tested by lightly tapping the medial or lateral canthus of the eye and observing whether the animal blinks in response. Generally present throughout stages I and II, diminished in Stage III and lost in Stage IV.
- **Swallowing** - Occurs spontaneously in awake animals. Usually stimulated by the presence of saliva or food in the pharynx. Monitored by observing movement in the ventral neck area. The swallowing reflex is lost at a medium depth of anesthesia and usually regained just before the patient recovers consciousness. The return of the swallow reflex during recovery indicates that it is safe to remove the endotracheal tube.
- **Pedal** - Elicited by pinching a digit and observing whether animal flexes the leg, withdrawing the paw. With inhalants, the pedal reflex is normally lost during induction.
- **Corneal** - Tested by touching the cornea with a sterile object (a drop of water or saline can be used) and noting whether the animal blinks and withdraws the eye into the orbit. This reflex is not commonly tested unless it is necessary to determine if the patient is too deeply anesthetized. Usually present until stage III, plane 4 anesthesia.
- **Laryngeal** - Stimulated when the larynx is touched by an object. The response is an immediate closure of the epiglottis and vocal cords. May be observed during intubation if the animal is not sufficiently anesthetized to allow the tube to be passed.

➤ **Jaw tone** - With increasing anesthetic depth, skeletal muscles become more relaxed and offer little resistance to movement. Jaw tone is one of the easiest ways to evaluate muscle tone.

- Jaw tone is assessed by attempting to open the jaws wide and estimating the amount of passive resistance. During anesthesia, it should be decreased but always present to some extent. Extreme laxity of the jaw suggests excessive anesthetic depth.
- The degree of muscle relaxation is dependent not only on the depth but also on the particular drugs administered to the animal and the animal's normal muscle tone.

➤ **Eye position, pupil size and pupillary light response** - (See 'Assessing Anesthetic Depth')

- In combination with other factors, the position of the eyeball and size of pupils may provide information regarding anesthetic depth. However, there is considerable variation among individual animals and anesthetic protocols.

➤ **Heart and respiratory rates**

- As indicators of anesthetic depth, the patient's heart and respiratory rates are only valuable in combination with assessment of other factors (reflexes, muscle tone, etc).
- In general, an abnormally low HR or RR may be associated with excessive anesthetic depth. Increased HR or RR may be the result of surgical stimulation or arousal.

➤ **Response to surgical stimuli**

- Minor changes in heart rate during surgery are considered normal. The absence of such a response may indicate an unnecessarily deep level of anesthesia.
- Animals perceiving surgical stimulation may show an increase in heart rate. This does not necessarily indicate that the anesthetic depth is inadequate unless the increase in heart rate is considerable and/or other changes in other parameters are noted.
- Surgical stimulation may also induce a decrease in heart rate due to increased vagal tone.
- Increased respiratory rate and signs of voluntary movement by the patient, however, do indicate insufficient anesthetic depth and perception of pain.
- Increased tear production, salivation and sweating (observed on the foot pads) also indicate that the patient may be perceiving painful stimuli and that the depth is inadequate.

➤ **Status of surgical procedure**

- The anesthetist should maintain communication with the surgical team regarding progress of the procedure and any problems or abnormalities that may occur.
- Familiarity with the procedure being performed allows the anesthetist to foresee changes in anesthetic requirements and adjust accordingly.

Equipment function

Regular evaluation of the anesthetic machine should become part of your standard monitoring routine. Equipment problems, either as a result of malfunction or human error are the cause of many common anesthetic complications. It is crucial that you are thoroughly comfortable with the setup and operation of the machine you will be using before you anesthetize a patient.

➤ **Vaporizer setting and anesthetic level**

- Observation of the vaporizer setting does not in itself indicate the patient's anesthetic depth as there is a tremendous variation in patient response. The concentration of anesthetic gas received by the animal will vary with the oxygen flow rate and quality of ventilation received by the patient. The vaporizer setting should be continually adjusted according to the depth of anesthesia and status of procedure.
- In general, a relatively high anesthetic dose (2.5-3%) will be required for the first several minutes after induction. When a stable anesthetic plane has been reached, the vaporizer setting is lowered and adjusted to maintain an appropriate depth. Once the most stimulating part of procedure is complete, it is usually possible to decrease the vaporizer setting gradually lowering the dose as the procedure nears completion.
- As a safety precaution, it is our policy that **the isoflurane vaporizer is never set higher than 3%**. If the patient needs to be more deeply anesthetized, increasing the oxygen flow rate and manually ventilating will increase the uptake of isoflurane.
- Periodically monitor the level of isoflurane in the machine. This should be done as part of your pre-anesthetic machine check, several times throughout the procedure and again at the completion of the procedure. If the isoflurane setting is below the half-way mark, be sure to fill the reservoir prior to beginning the procedure.

➤ **Oxygen flow meter setting**

- In general, an oxygen flow rate of 0.5-2 L/min is appropriate for most patients.
- If the reservoir bag is overfilling and the animal is breathing normally, check that the pop-off valve is open then reduce oxygen flow to maintain an appropriate volume in the bag.

➤ **Pressure relief (pop-off) valve**

- The pop-off valve should be in the OPEN (or mostly open) position except when manually ventilating (bagging) the patient.
- The pop-off valve prevents the build-up of excessive pressure or volume of gases in the circuit. If allowed to occur (as when the valve is left in the closed position), this pressure can reach the animals lungs, causing the alveoli to distend and eventually rupture.