Anesthetic Monitoring

The majority of an anesthetic episode is devoted to monitoring the patient. The ability to evaluate physiologic values and respond to them appropriately will ensure the safest anesthesia possible with minimal decrement to organ function.

Monitoring Equipment

There are two types of anesthetic monitoring equipment, **invasive** and **non-invasive**.

Invasive monitoring refers to any equipment that has to be placed in the body and non-invasive refers to any equipment that read variables that are readily apparent. Non-invasive equipment is simple and easy to use but not always as accurate when compared to invasive equipment. Advanced technical skill and knowledge is needed to place invasive equipment and there is a chance for complications, such as hemorrhage, and/or infection.

Non-invasive monitoring equipment:

ECG (Electrocardiogram)

- A visual representation of heart conduction and provides a heart rate.
- Allows you to assess heart rhythm, electrical conduction though the heart, and identify arrhythmia's
- Normal heart rate: Dogs 70-100 BPM, Cats 100-200 BPM.
- Disadvantage: Does not indicate cardiac function and can look normal even though peripheral blood pressure is compromised.

SpO2- (Pulse Oximetry)

- Measures the **oxygen saturation** in blood and **gives a pulse rat**e.
- Provides a visual pulse waveform.
- Disadvantage: Has to be moved frequently due to capillary's being crushed under the compression caused by the monitoring device. Unreliable at low saturation levels and difficult to get a reading if tissue has dark pigmentation.

Blood Pressure (Doppler/sphygmomanometer, oscillometric)

- **Dopplers** monitor systolic blood pressure using an ultrasonic doppler, sphygmomanometer, and inflatable cuff. The Doppler method also gives an audible representation of pulse rate.
- **Oscillometric** devices provide systolic, mean, and diastolic pressures using an inflatable cuff.
- Normal blood pressure range: Systolic: 100-160 mm Hg, Mean: 80-110 mm Hg, Diastolic: 70-90 mm Hg.
- Disadvantage: **Accuracy depends on correct cuff size**.

Capnography

- Measures the **end tidal and inspiratory carbon dioxide** and anesthetic gas concentration. The capnograph also provides a respiratory rate and waveform.
- End tidal CO_2 readings are 5-10 mm Hg lower than actual alveolar concentrations.

- Allows you to access systematic metabolism, cardiac output, pulmonary perfusion, and the adequacy of patient ventilation.

Temperature probe

- Used to monitor the core temperature of the animal.
- **Normal Temperature Range: Dogs 101-102.5F, Cats 100.5-102.5F,** (anesthesia causes hypothermia)

Invasive Monitoring Equipment:

CVP (Central Venous Pressure)

- Indicates **fluid status** and **assesses cardiac output**.
- Normal range: 0-4 cm H2O – standing awake, 2-7 cm H2O anesthetized.
- Higher readings than normal indicate hypervolemia or myocardial depression/heart failure and lower readings indicate hypovolemia.

Blood Pressure (arterial catheter)

- Gives a constant systolic, mean, and diastolic blood pressure values along with a visual waveform.
- The waveform can be used to evaluate whether cardiac arrhythmias may be causing poor pressures or when pulse deficits become detrimental to the patient. The waveform can also indicate the presence of vasodilation or vasoconstriction.

Blood Gas

- Blood Gas – (pH, Lactate, partial pressure of oxygen and carbon dioxide, bicarbonate)
- Gives and accurate representation of the respiratory function and acid-base balance
- **Must be taken from an artery** to evaluate respiratory function.
- Normal values for an arterial blood gas: PH – 7.35 – 7.45 $PaCO_2$ – 35-45 mm Hg, PsO_2 90-115 mm Hg on room air, if the patient is on 100% oxygen the PsO_2 = 500 mm Hg, SaO_2 - >95%, HCO_3 - 18-26 mEq/L, BE- -2 to +2.

Hands-On Monitoring

Sophisticated monitoring equipment is not the only way to assess the status of an anesthetized patient. There is a variety of information that can be acquired using hands-on monitoring.

Anesthetic Depth:

- **Eye position –** During a surgical plane of anesthesia eyes roll ventrally. The eye will be central during light and deep planes of anesthesia. Dissociative anesthetics will keep the eye central during all planes of anesthesia.

- **Palpebral Reflex –** Only present during a light plane of anesthesia. Tapping the medial/lateral canthus elicits a response.
- **Withdrawal Reflex –** Only present during a light plane of anesthesia. Performed by pinching a toe and is often used to access whether an animal is deep enough for endotracheal intubation during a masked induction.
- **Jaw Tone –** Indicates muscle relaxation that varies with anesthetic depth.

Respiratory and Cardiovascular:

- **Mucus Membrane Color –** Ascertained at the gingiva, vulva, and eyelids. Pale mucus membranes may indicate vasoconstriction, decreased cardiac output, hypoxia, and anemia. Dark pink mucus membranes may indicate vasodilation, sludging of blood in the capillaries, and high CO2 levels. Cyanotic mucus membranes indicate severe hypoxemia and a yellowish hue indicates high serum bilirubin from hemolysis or hepatic disease.
- **Capillary Refill Time –** Normal capillary refill time is less than 2 seconds and can be assessed at the gingiva, vulva, and eyelids. A capillary refill time of more than 3 seconds is significant and is indication of a low cardiac output and poor tissue perfusion.
- **Palpation of arteries –** An arterial pulse can be felt at the femoral, lingual, dorsal pedal, digital, and buccal artery. Pulse rate, rhythm, and pulse pressure can be assessed. It is important to note that pulse pressure does not indicate perfusion pressure.

Common complications during maintenance anesthesia

Tachypnea

Tachypnea can be caused by a light anesthetic plane, pain, hypercarbia, hypovolemia, hypoxemia, drugs, and cerebral spinal fluid acidosis.

Apnea

Apnea can be caused by a deep anesthetic plane, hypothermia, recent hyperventilation, musculoskeletal paralysis, and drugs.

Tachycardia

Tachycardia can be caused by a light anesthetic plane, pain, hypotension, hypoxemia, hypercarbia, ischemia, acute anaphylactic reaction, anemia, and drugs.

Bradycardia

Bradycardia can be caused by a deep anesthetic plane, hypertension, increased intracranial pressure, surgical vagal reflex, hypothermia, hyperkalemia, myocardial ischemia, and drugs.

Hypertension

Hypertension can be caused by a light of an anesthetic plane, pain, hypercarbia, fever, and drugs.

Hypotension

Hypotension can be caused a deep anesthetic plane, hypovolemia, sepsis, shock, and drugs.

One cause of a low SPO2 is if the **endotracheal tube has been inserted too far**. This can easily happen in a small dog or cat. If you induce a patient and the SPO2 is immediately low and the animal is not oxygenating properly, double check the endotracheal tube and measure it again; it may need to be pulled out a little. This is why it is so important to measure the tube prior to intubation.

Maintenance anesthesia guidelines

Being prepared is the first step in preventing complications from arising. A thorough monitoring plan made before animal is anesthetized based on the patient's history, health status, specific procedure, and anticipated duration of anesthesia will allow the anesthetist to prepare for and/or prevent complications.

The key to anesthetic monitoring is making the correct assessment when a complication arises. Always evaluate more than one body system and more than one variable per system. Never totally depend on just one piece of monitoring equipment and double check values against different techniques and compare. For example, check the heart rate by counting it off the audible sound of the Doppler and compare it to the read out from the ECG, or by auscultation the chest to confirm accuracy. It is also important to check machine calibrations frequently. Inaccurate information can be confusing, misleading, and dangerous.

A detailed anesthetic record is also helpful in determining the cause of a complication. A history of trends of physiologic variables and events will increase the likelihood of a correct diagnosis. Records are also helpful for future anesthetic episodes by providing a history of the patient's performance.

References:

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