Anesthesia Monitoring

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Anesthesia can be divided into four progressive phases. The signs relating to a certain phase are based upon the presence or absence of certain reflexes which are progressively lost as the amount of administered anesthetic increases. The time when reflexes are lost varies with the drug used.

Phase I

This is the stage of voluntary excitement marked by struggling and breath holding if induction is slow and by inhalation. Respiratory rate and pulse rate are increased and the pupils are dilated. Urination and defecation frequently occur. These are signs of the fear response.

Phase II

In this stage, loss of consciousness occurs. Ventilation is irregular and involuntary excitement may occur.

Phase III

The stage of surgical anesthesia. Ventilation is regular. This stage can be loosely divided into three planes of progressive depression of cardiopulmonary function and responsiveness to stimuli.

In **plane one** painful stimuli may cause an increase in heart rate, blood pressure and respiratory rate. The palpebral reflex is present (the palpebral reflex is stimulated by tapping the skin at the medial canthus of the eye or by running the finger along the eyelashes. The reflex disappears in light to medium plane of surgical anesthesia in small animals). Lacrimation is not depressed so the cornea still looks "shiny". In dogs and cats the eyeball is centrally positioned.

In ***plane two*****,** the laryngeal reflexes are lost. There is further depression of the cardiopulmonary system. The eyeball rotates down in cats and dogs under halothane, isoflurane, barbiturate and propofol anesthesia. The palpebral reflex is lost. ***This plane is adequate for nearly all surgical procedures.***

In **plane three**, respiration becomes more depressed and the breathing pattern becomes diaphragmatic in cats and dogs. Cardiac contractility and blood pressure is further reduced. In cats and dogs the eyeball becomes central and there is no palpebral reflex. Lacrimation also ceases, and the cornea looks dry. This plane is a warning that the animal is receiving too much anesthetic and should be `lightened'!

Phase IV

Overdose. Paralysis of the intercostal respiratory muscles occurs and weak diaphragmatic movements are made. With further deepening these also disappear. The abdomen looks as if it is bulging out and the thorax caving in during inspiration. The pulse becomes weaker. The pupils start to dilate and the cornea looks very dry. If these warning signs go unheeded there is complete paralysis of the medulla of the brain, and cardiopulmonary collapse. If the anesthetic is withdrawn (inhalational agents) and artificial respiration instituted before profound cardiovascular depression occurs, then recovery is possible. With parenteral anesthetic agent overdose, reversal agents can be used, but not all parenteral drugs have reversal agents.

The overall goal of monitoring anesthetized animals is to ensure adequate tissue perfusion with oxygenated blood.

The reflex responses used to determine the depth of anesthesia are:

- **Pedal** (digital withdrawal) reflex. The reflex is obtained by firm pressure of the interdigital skin in the dog and cat, squeezing the claws together in cattle and swine and firm pressure on the pastern of horses. The reflex disappears late in phase III and indicates deep anesthesia. When checking the reflex, the legs should be held in extension. Probably more useful in monitoring laboratory animal patients and birds.
- **Palpebral reflex.** The palpebral reflex is stimulated by tapping the skin at the medial canthus of the eye or by running the finger along the eyelashes. The reflex disappears in light to medium plane of surgical anesthesia in small animals.
- **Corneal reflex.** The corneal reflex is obtained by gentle palpation of the lateral aspect of the cornea. This causes reflex closure of the eyelids. The reflex disappears in the deeper levels of phase III, plane II. This reflex is not always reliable in the dog, particularly if the eyeball is markedly rotated.
- **Lacrimation.** Tear formation
- **Yawning.**
- **Swallowing.**

- **Laryngeal reflex.** The laryngeal reflex, which is stimulated by attempting to pass an endotracheal tube, also disappears in light anesthesia.
- **Anal reflex.** The anal reflex is a contraction of the anal sphincter muscle on sudden manipulation of the anus. This reflex disappears in the middle of phase III in the dog and cat.
- **Pupillary responses.** The pupillary responses under anesthesia are heavily influenced by pre-medication. Species variations exist. There is also variability in response to different anesthetics. In general, in un-premedicated patients, the pupil is dilated in the early excitement phase and then becomes progressively constricted as surgical anesthesia occurs. With very deep surgical anesthesia the pupil begins to dilate again and with entry into phase IV, with respiratory and cardiac arrest, the pupil is maximally dilated.
- **Eyeball position.** The position of the eyeball varies markedly depending on anesthetic agent employed and the species of animal. In small animals at a stage of surgical anesthesia with halothane and isoflurane, the eyeball is rotated medially and ventrally. In the early stages and in late stages with very deep anesthesia, the eyeball is centrally placed.
- **Muscle relaxation.**

1. *Why should we monitor anesthetized patients?*

Monitoring circulation, oxygenation and ventilation in the anesthetized patient allows the veterinary anesthetist to identify problems early, institute treatment promptly, and thus avoid irreversible adverse outcomes.

2. *What parameters should be monitored?*

The American College of Veterinary Anesthesiologists (ACVA) developed a set of guidelines for monitoring anesthetized patients. The ACVA recommends that *circulation, oxygenation, and ventilation* of the anesthetized patient should be monitored.

The objective of monitoring the circulatory system is to ensure adequate blood flow to tissues during all anesthetic procedures. The objective of monitoring oxygenation in the anesthetized patient is to ensure adequate oxygen concentration in the patient's arterial blood. To ensure adequate ventilation, the ventilatory function of the anesthetized patient needs to be monitored. In addition, the depth of anesthesia and patient core body temperature should also be monitored during general anesthesia.

3. *How to monitor the anesthetized patient?*

Subjective and objective monitoring of anesthetized patients

Subjective monitoring involves using the anesthetist's visual, touch, and auditory senses to assess the patient's vital signs.

Circulation (cardiovascular function)

Subjective methods:
The *subjective* assessments of an anesthetized patient's circulatory system have been published by the ACVA. These include palpation of peripheral pulse, palpation of the heartbeat through the chest wall, and auscultation of heart beat. Use of a regular stethoscope, esophageal stethoscope, or other audible heart sound monitor aids the anesthetist in assessing the "presence", "absence", "regularity" or "irregularity" of a patient's heart beat. Palpation provides a subjective feeling of "presence" or "absence"; "strong" or "weak"; "regular" or "irregular" peripheral pulse.
Assessing capillary refill time provides a subjective assessment of tissue perfusion. A prolonged capillary refill time suggests poor tissue perfusion.

Objective methods
Used to clinically assess circulation in the anesthetized patient include using *Electrocardiography (ECG*) and determination of Blood Pressure.
Arterial blood pressure: Measurement of arterial blood pressure provides information regarding the adequacy of blood flow to the patient's tissue. If the anesthetized patient has a mean arterial blood pressure below 60 mmHg, organ and tissue perfusion is inadequate. In addition to mean arterial blood pressure, systolic and diastolic blood pressure provides useful information concerning peripheral vascular resistance, stroke volume, and intravascular volume. Normal systolic blood pressure range for anesthetized dogs and cats is between 90 mmHg and 120 mmHg. Diastolic blood pressure ranges between 55 mmHg and 90 mmHg.

Oxygenation (cardiorespiratory function)

Subjective methods:
Clinically, the presence of pink mucous membranes in an anesthetized patient is subjectively indicative of acceptable oxygenation. However, oxygenation is either difficult or not possible to assess in anemic patients or patients with peripheral vasoconstriction. These patients usually have pale mucous membranes.

Objective methods for evaluating a patient's oxygenation include
Using blood gas analysis for PaO2 (partial pressure of oxygen in the arterial blood), hemoximetry, and pulse oximetry. Pulse oximetry provides a non-invasive, continuous detection of pulsatile arterial blood in the tissue bed, calculates the percentage of oxyhemoglobin present in the arterial blood, and provides the pulse rate of the monitored patient. Proper functioning of the pulse oximeter may be affected by many situations. These include motion artifact (e.g, shivering), ambient

light, poor peripheral blood flow from hypotension and vasoconstriction, electrical noise from electrocautery, increased carboxyhemoglobin and methemoglobin levels and dark skin color.
Normal pulse oximeter readings in anesthetized animals should be 99-100%. Hypoxemia (insufficient oxygenation of arterial blood) is considered to be present in the anesthetized patient, when the reading is less than 90%.

Ventilation (respiratory function)

Subjective evaluation of an anesthetized patient's ventilation efficiency:
May be done by observing chest wall movement or re-breathing bag excursion when the patient is connected to an anesthesia machine. Auscultation of breathing sound via an esophageal stethoscope or an audible respiratory monitor provides only respiratory rate and the absence or presence of respiration.

Objective evaluation and monitoring of ventilation efficiency requires respirometry, blood gas analysis, or capnometry.

Monitoring Other Parameters

Hypothermia:

Causes

- Loss of the shivering response
- Increased heat loss
- Vasodilation
- Cool operating room
- Open body cavities
- Surgical prep
- Cold tables

Prevention of Hypothermia

- Avoid contact with cold tables
- Minimize anesthesia/surgery time
- Minimize alcohol contact with non-surgical areas
- Warm water blankets, not heating pads
- Drape appropriately
- Recovery in warm place

Treatment of Hypothermia

- Blanket
- Body contact
- Warm water blankets

- Hot water bottles
- Heater/ hair dryer
- Warm IV fluids
- Warm water enema

Hypothermia: VERY COMMON!

Normal doses of anesthetics in hypothermic animals will result in anesthetic overdose! Hypothermia itself is an anesthetic. Active re-warming is necessary

Malignant Hyperthermia

Common in dogs, pigs, humans. Rapidly fatal if untreated.

Induced by halothane, succinyl choline. Treated with Dantrolene