

Induction and recovery are the two times during an anesthetic episode where a patient's state of consciousness is altered. During induction, a patient is transferred from a state of consciousness to a state of unconsciousness. This process is reversed during recovery. It is important to understand signs, equipment, and methodology to make this transition for the patient as easy as possible and to avoid unnecessary complications.

Induction

Routes of Delivery: Injectables vs. Inhalants

Injectables

- **Usually the preferred method** of induction; less stressful due to the fast-acting nature of the drugs.
- **More than one drug can be given** and more than one route can be used to deliver induction agents.
- Some injectable drugs can be given intravenously or intramuscularly.
- The downside to injectable agents is that, once they are given, they cannot be controlled and are not immediately eliminated.
- **Intramuscular injections take longer to work than intravenous injections, and are often used for animals that are hard to handle.**

Inhalants

- Patients **induced with inhalants** experience a **prolonged** stage two of anesthesia, also known as the **“excitement phase.”**
- During **stage two of anesthesia**, the animal can become **anxious, especially if no premedication** is used.
- **Gas induction** may be an option for animals that are **too aggressive to touch** or who are very small, although this is usually avoided when possible.
- Inhaled agents can be delivered to the patient in two ways, by holding a gas mask up to the patient's face or placing the patient in a sealed chamber where the animal is immersed in inhalant anesthetic.

- When using an induction chamber, **make sure the chamber is big enough for the patient to lay down with an extended neck.** High oxygen flow rates of 3-5 liters per minute and high gas concentrations of 3-4% for isoflurane and 4-5% for sevoflurane are used to speed up induction. **Once the animal appears anesthetized, remove the animal from the chamber and attempt endotracheal intubation.** If the patient is not adequately anesthetized to allow for intubation, a mask can be used to administer more anesthetic gas to deepen the anesthetic plane.
- Mask induction exposes the anesthetist to less anesthetic than using an induction chamber.
- When using mask induction, start the vaporizer setting at 0.5% and increase in 0.5% increments every 30 seconds until the patient is sedate, to reduce the animal's stress. Be sure to use the appropriate size mask and diaphragm to reduce the amount of dead space and gas leakage.

Common Injectable Induction Agents

It is imperative to know the history of the animal before choosing an anesthetic drug protocol. Disposition, concurrent health problems, health status, and reason for anesthesia will aid in deciding the safest and most appropriate anesthetic induction protocol for the patient. **Pre-medicating the patient prior to induction will also lessen the amount of induction drugs needed to sedate the patient.**

Propofol

- Rapid acting
- Quickly eliminated from the body by hepatic and extrahepatic metabolism
- **Potent respiratory depressant**, may cause **apnea** after induction
- Can cause **hypotension due to vasodilatation**
- **Does cross the placental barrier but with minimal depressant effects on the fetus**
- Intravenous administration only

Etomidate

- Rapid acting
- Produces a **hypnotic-like state** that doesn't completely sedate the patient. Therefore, inductions can be rough
- Eliminated by **hepatic metabolism**
- Administration **can be painful** due to the propylene glycol carrier.
- **Does not affect cardiovascular system**
- Does cross the placental barrier but with minimal depressant effects on the fetus.
- Intravenous administration only

Benzodiazepines

- The **most common benzodiazepines** used for induction are **diazepam, midazolam, and zolazepam**.
- **Reduce anxiety and provide skeletal muscle relaxation**
- **Always given with another induction agent** because they do not provide sedation and may cause excitement (e.g., ketamine and diazepam are usually given together).
- Eliminated by **hepatic metabolism**
- **Diazepam contains propylene glycol, which can be irritating to tissues and causes the drug to have an unreliable absorption rate when given intramuscularly.**
- Diazepam is **not water soluble and can only be mixed in a syringe with ketamine.**
- Zolazepam is the benzodiazepine part of the mixture known as Telazol.
- Can be given **intravenously or intramuscularly**

Cyclohexamines

- The **two most common cyclohexamines** used for induction are **ketamine and tiletamine**.
- **Stimulate the central nervous system**, rather than depress it like most other induction drugs.
- Produce muscle **rigidity and sensitivity to light, sound, and touch**. These effects can be reduced by using other drugs in combination with cyclohexamines.
- Increase heart rate, blood pressure, and intraocular pressure
- **Not recommended for patients with ocular disease**
- **Recovery** can be rough as patients tend to be **dysphoric**.
- **Ketamine is metabolized via the liver in the dog and kidney in the cat. Tiletamine is metabolized via the kidneys in both animals.**
- Tiletamine is the cyclohexamine part of the mixture known as Telazol.
- Can be given **intravenously or intramuscularly**

Barbiturates

- The two most common **barbiturates** used for induction are **thiopental and methohexital**.
- **Rapid onset of action**
- Causes **respiratory and cardiovascular depression**
- Metabolized **hepatically and extra-hepatically**
- **Redistributes to lipid areas** of the body. **Use with caution** in lean animals, such as **sighthounds**, as low levels of body fat will produce more pronounced central nervous system depression.
- Contraindicated for cesarean sections or patients with cardiac, hepatic, or respiratory disease. Barbiturates are also contraindicated in patients with hypoproteinemia, acidosis, or hypothermia.

- **Thiopental** has a **cumulative effect** with repeated doses.
- **Methohexital** **does not have cumulative effect** and does not redistribute into highly lipid tissues as heavily as thiopental does.

Endotracheal Tube Placement

- **After induction, the animal is intubated with an endotracheal tube** (even if maintenance with a gas anesthetic is not in the plan).
- An endotracheal tube will **prevent the aspiration of foreign material into the lungs, provide an effective way to deliver oxygen to the patient**, and allow for intratracheal delivery of emergency drugs.
- **Before intubating, the patient should be pre-oxygenated with 100% oxygen** and the endotracheal tube's inflatable cuff **should be checked for leaks**. The endotracheal tube is then placed against the animal's throat, with the cuffed end just caudal to the thoracic inlet, to ensure adequate length.
- Once the animal is induced, an assistant positions the patient's head for intubation. Place the **laryngoscope blade on the tongue, just before the epiglottis, and apply downward pressure** to expose the tracheal opening. **Slide the endotracheal tube past the arytenoids into the trachea.**
- Attach the breathing circuit and turn on the gas. Confirm endotracheal placement by lining up the markings of a similar size endotracheal tube with the placed tube. Lay the placement tube next to the animal's throat to visualize placement of the caudal tip and adjust if needed. **Once placed, tie the tube securely in place and inflate the endotracheal cuff.**

Recovery

- The **last stage** of the anesthetic episode is **recovery**.
- **Anesthetic agents are discontinued and the patient returns to a conscious state.**
- After the inhalant is stopped, the **oxygen rate is increased** to four liters for ten minutes to **"wash out" inhalant anesthetic from the machine and patient.**
- **Oral monitors are also removed** in case of a sudden return to consciousness.
- Once the patient has been thoroughly oxygenated, the anesthetic machine can be disconnected and the patient moved to a cage in an intensive care unit.
- **The most beneficial position is sternal recumbency** with the animal's head propped up in a natural position to maintain a proper airway and reverse any positional atelectasis. However, this isn't always possible due to the location of the surgical site or type of surgery. If sternal recovery isn't possible, the patient should be placed in a comfortable position without putting any pressure on surgical incisions.

- The recovery period should be planned with a pre-warmed cage and proper bedding. The patient **should not be left alone during recovery and vitals should continue to be monitored to ensure a smooth transition during the recovery phase.**
- **Wait a couple of hours before removing catheters in case complications arise** and intravenous and/or arterial access is needed.

Temperature

- Hypothermia increases recovery time.
- **Heating devices** (such as a **Bair hugger**) are used to **raise the animal's body temperature quickly.**
- **Monitor temperature** until normal and to **ensure the animal does not become overheated.**
- Patients that are recovering may be unable to move to a cooler part of the cage if they become hyperthermic.
- Heating devices should also be periodically checked during a patient's recovery to ensure they are not causing burns.

Anxiety

- Anxiety can become an issue during recovery and may have a variety of causes.
- The animal could become **dysphoric** due to drugs used during the procedure (e.g., ketamine), or could be **responding to hunger, fear, a full bladder, or pain.**
- Pain and dysphoria can be hard to distinguish because their presentations are similar. It's important to **administer analgesics before the recovery phase** to alleviate any pain and make dysphoria a more likely cause for anxiety.

Endotracheal Tube Removal

- Often patients will recover with an endotracheal tube in place and it is important to know how and when to remove the tube.
- The tube should not be removed until the patient is **actively swallowing** to ensure gag reflex has returned. Removing it before this time could lead to complications such as **aspiration or decreased oxygenation.**
- The endotracheal tie should be kept in place until the patient is put in its final recovery area to prevent accidental extubation.

- The endotracheal cuff should be kept inflated until right before extubation to guard against regurgitation.
- The extubation of a brachycephalic breed (ex. English bulldog) should be delayed as long as possible. Brachycephalic animals have long soft palates, large tongues, and small tracheas in contrast to their body size, making airway obstruction more common than in other breeds.

References

- McKelvey, D, Hollingshead, KW. 2000. Small Animal Anesthesia and Analgesia, 2nd ed. St. Louis: Mosby.
- Bryant 2010. Anesthesia for Veterinary Technicians, Iowa: Wiley-Blackwell.
- Muir, Hubbell, Bednarski, Skarda. 2007. Handbook of Veterinary Anesthesia, 4th ed. St. Louis: Mosby.