

# CANINE & FELINE ANESTHESIA

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## CANINE ANESTHESIA

### Introduction

- A general anesthetic to a healthy dog should bear little risk to the animal's life. However, although the mortality rate is very low, morbidity due to anesthesia, which is often overlooked, is not uncommon
- In man severe hypoxic brain damage can decrease intelligence following general anesthesia which is apparent to families and friends, and similar happenings may occur in dogs
- Owners may comment that their dog is never the same since the anesthesia which may indicate a cerebral anoxic damage
- A more dramatic and obvious cause of postanesthetic morbidity in dogs is renal failure
- Many elderly dogs suffer from some degree of interstitial nephritis and in such animals even mild renal hypoxia may prove fatal within a relatively short time
- Many choices are available to tailor anesthetic protocols to meet the demand of increased sophistication of diagnostic and surgical procedures, and with smooth induction, careful monitoring in oxygenation, circulation and ventilation, and attention to fluid balance and smooth recovery, a safe anesthesia in dogs can be ensured

### Preanesthetic preparation

- Starvation for about 12 hours usually ensures a dog will have an empty stomach
- Water need not be deprived until premedication is given or until about 2 hours prior to anesthesia
- Laboratory evaluation can provide useful prescreening information about the general health status of the patient prior to anesthesia, and minimum database are PCV, TP, BUN and glucose
- A thorough physical examination to determine any abnormalities must be carried out. Auscultation for cardiac dysrhythmias and murmurs, or abnormal lung sounds will provide useful information regarding preexisting cardiopulmonary disease.
- Stabilize animal's physiology in debilitated animals (e.g. fluid deficit, acid-base abnormality)
- IV catheterization placement
  - o The common site of venous catheterization site is cephalic vein
  - o Other veins for venous catheter placement include the recurrent tarsal, saphenous, auricular and jugular veins
  - o For jugular catheterization 16 – 18 G and 2-6 inch long catheter is suitable for most dogs

### Preanesthetic agents

- A good preanesthetic sedation facilitates smooth induction and has anesthetic sparing effect during maintenance
- There are many choices available. Sedative/opioid combination (neuroleptanalgesia) is most popular (e.g. acepromazine and morphine), and provides better restraint and analgesia (the combination is synergistic, not merely additive) as preanesthetic medication

### Acepromazine

- Provides mild sedation at clinically prescribed dose (0.01 – 0.05 mg/kg IV, IM, SQ)
- Anti-arrhythmic
- Requires at least 20 min for good effect even after IV injection, and 30 to 45 min when given IM, and longer for SQ
- Prolonged duration
- Premedication dose of 0.04 mg/kg IM has minimal cardiovascular effect in healthy dogs
- Will cause hypotension (more so in old, debilitated, or hypovolemic animals) through direct myocardial depression and peripheral vasodilation, and should not be used in these debilitated animals.
- Decrease seizure threshold, so better to avoid in patients at increased seizure risks
- Some strains of the Boxer breed is very sensitive to phenothiazine and acepromazine as little as 0.02 mg/kg IM can cause collapse with the animal becoming very bradycardic and hypotensive. As the symptom is very similar to vasovagal stimulation, it is recommended low dose of acepromazine be given, and atropine or glycopyrrolate be given with acepromazine in this breed.
- Inexpensive, and very widely used for sedation and premedication

### Diazepam/Midazolam

- Minor tranquilizer
- Excellent muscle relaxation
- Minimal cardiopulmonary depression
- May cause paradoxical excitement through disinhibition, so best to be given with other CNS depressants (e.g. ketamine, opioids)
- 0.05 – 0.4 mg/kg IV, IM, SQ
- Diazepam is more irritant to the tissue so better to avoid giving it IM

### Xylazine

- Has potent sedative effect, but cardiovascular depression can be profound
- Causes vomiting
- Other side effects as seen in other species also occur
  - Hyperglycemia
  - Diuresis
  - GIT motility depression
  - Platelet aggregation
- Largely displaced by medetomidine in small animals

## Medetomidine

- Causes less vomiting than xylazine
- 5-40 mcg/kg IM, SQ have been given to produce sedation. IV administration is associated with more severe form of dysrhythmias, so generally is not recommended
- Sedation lasts approximately for one hour
- The pharmacologic effects of medetomidine in dogs are very similar to those of xylazine in that it causes bradycardia, hyperglycemia, and increased urine production. An exception is that it causes arterial hypertension which is dose-dependent

## Romifidine

- The most recent alpha 2 agonists
- Reduces the amount required for the anesthetic induction in dose dependent manner
- Produces dose dependent cardiovascular depression
- 10-80 mcg/kg IM, SQ

## Opioids

- Widely used to provide analgesia in dogs
- Provide better sedation and analgesia when combined with other sedatives
- Morphine is inexpensive and is used in the dose of 0.25-1 mg/kg IM, SQ.
- IV morphine induces histamine release particularly if given as a rapid bolus, but slow administration is less likely to cause problems
- Oxymorphone causes less vomiting than morphine and hydromorphone, so is better choice for patients with head trauma, eye injury and gastrointestinal disorders.
- Combination of benzodiazepines with butorphanol (or buprenorphine) is a useful alternative to the combination with pure opioids for brachycephalics reducing the risk of respiratory depression
- Opioids induce minimal cardiovascular depression
- See pain lecture for other available opioids

## Anticholinergics

- Anticholinergics are not routinely administered as part of preanesthetic medication
- Use of atropine or glycopyrrolate may be indicated for animals with high resting vagal tone (e.g. brachycephalics) and procedures likely to increase vagal stimulation (e.g. ocular surgery)
- Recommended dosages are; atropine 0.02-0.04 mg/kg IV, IM, SQ; and glycopyrrolate 2-10 mcg/kg IV, IM, SQ

## Anesthetic Induction

### Ketamine

- The dose of ketamine which produces anesthesia in dogs is very near to that which causes seizures
- Ketamine is associated with increased muscle rigidity and excessive salivation
- Ketamine may cause increased heart rate, cardiac output, and blood pressure
- A wide range of sedatives are combined with ketamine to induce deep sedation or light anesthesia
  - o Ketamine- Medetomidine / Xylazine
    - ▼ Medetomidine at 5 – 40 mcg/kg added to ketamine at 2-5 mg/kg given either IM or IV produces deep sedation often recumbency. Butorphanol 0.1-0.4 mg/kg IV, IM can be included in this combination for better sedation, analgesia and muscle relaxation. Although the combination can be given SQ the onset of anesthetic effect is less predictable
    - ▼ Medetomidine can be substituted by xylazine 0.1-0.5 mg/kg, resulting in shorter duration of effect
  - o Ketamine-Diazepam/Midazolam
    - ▼ This combination will produce less cardiovascular depression than xylazine-ketamine
    - ▼ Diazepam 0.1-0.4 mg/kg and ketamine 5 mg/kg given IV as a bolus or titrated to effect, or IM injection produce recumbency and status similar to general anesthesia in 2-10 minutes
    - ▼ Midazolam is administered at 0.1 – 0.3 mg/kg IV, IM, substituting diazepam
    - ▼ Butorphanol 0.1-0.4 mg/kg IV, IM can be included in this combination for better sedation, analgesia and muscle relaxation.

### Tiletamine and Zolazepam (Telazol)

- Typically used to provide deep sedation in intractable dogs
- Telazol up to 4 mg/kg IV to effect or IM produces deep sedation or light anesthesia
- Side effects associated with ketamine-diazepam use can also be seen (emergence delirium, hypersalivation)
- Other sedatives and opioids can be mixed to make the final constituent more potent so as to increase sedation, analgesia and duration of effect, and reduce side effects (e.g. emergence delirium)

### Thiopental

- The solution of thiopental have a very high pH and the drug can only be given intravenously
- Induction in unpremedicated dogs can be achieved at the dose of 15 mg/kg IV given the half dose as a rapid bolus and the remaining given titrated to effect
- In lightly premedicated dogs 7 mg/kg is sufficient to induce anesthetic induction
- Recovery is through redistribution of the agent from the brain into the other tissues
- Multiple administration will require the drug to be metabolized, and the dog will have a prolonged recovery with hang-overs lasting for 24 hours or more.
- Maximum total dose for a fit dog is 30 mg/kg

### Propofol

- It provides rapid induction and is very rapidly eliminated from the plasma.
- 6 mg/kg IV is calculated dose for the anesthetic induction. Respiratory arrest is not uncommon particularly with rapid IV bolus. It is best given as titrated to effect to produce anesthetic depth just enough to allow endotracheal intubation by slow administration
- It is non-accumulative and maintenance of anesthesia for prolonged duration can be achieved using a constant rate of infusion.

### Inhalation Agents (Isoflurane, Halothane, Sevoflurane, or desflurane)

- General anesthesia can be induced by administering isoflurane, halothane, sevoflurane, or desflurane via a facemask
- There are two methods; ‘incremental’ or ‘crash’ induction
- ‘Incremental’ induction technique uses 3 min of preoxygenation and then introduction of 0.5 % vapor setting for 30-60 seconds and then 0.5 % increment for the same period. ‘Crash’ induction is achieved with 3-5 % vapor set of isoflurane following pre-oxygenation. The dog will more likely struggle with the crash induction method
- It is preferable to use non-rebreathing circuits for quicker induction and then switched to the circle rebreathing systems (e.g. for animals weighing more than 6 kg)

*Some sample doses of injectable anesthetics in the dog*

Comb. #	Premedication	Dose mg/kg	Induction agents	Dose mg/kg
1	Acepromazine ± Morphine	0.02-0.05 0.25 – 1.0	Thiopental Propofol	15 “to effect” 6 “to effect”
2	Acepromazine ± Butorphanol	0.02-0.05 0.1 – 0.4	Thiopental Propofol	15 “to effect” 6 “to effect”
3	Midazolam ± Morphine	0.1-0.3 0.25 – 1.0	Thiopental Propofol	15 “to effect” 6 “to effect”
4	Midazolam ± Butorphanol	0.1-0.3 0.1-0.4	Thiopental Propofol	15 “to effect” 6 “to effect”
5	Midazolam ± Butorphanol	0.1-0.3 0.1-0.4	Ketamine	5 “to effect”
6	Medetomidine	0.002-0.04	Diazepam Ketamine	0.25 + 5 “to effect”
7	Medetomidine ± Butorphanol	0.002-0.04 0.1-0.4	Ketamine	5 “to effect”
8	Xylazine ± Butorphanol	0.3-0.5 0.1-0.4	Diazepam + Ketamine	0.25 + 5 “to effect”
9	Medetomidine ± Butorphanol	0.002-0.04 0.1-0.4	Thiopental Propofol	10 “to effect” 4 “to effect”
10	Midazolam ±Hydromorphone	0.1-0.3 0.05-0.2	Thiopental Propofol	15 “to effect” 6 “to effect”

## Endotracheal intubation

- Tracheal intubation in dogs are relatively easily achieved. They can have the mouth wide open and the laryngeal structures are easily viewed
- Use of laryngeal scope may facilitate the intubation
- The laryngeal spasm is uncommon, but the animal still needs to be adequately anesthetized to avoid head shaking or excessive coughing reflex
- Following intubation, correct placement can be confirmed by mild cough, feeling air coming out of the ET tube in synchrony of movement of the chest. If available, reading of CO<sub>2</sub> by a capnography is a useful method to confirm the correct position of the tube
- Endotracheal tube sizes are proportional to the body weight, typically using 8-12 mm for average 12 - 24 kg dogs. Brachycephalics tend to have hypoplastic trachea and an English bull dog weigh as much as 25 kg could only accept ET tube of 6 mm
- The cuff needs to be well sealed to prevent aspiration of regurgitants and also to maintain stable anesthetic depth, and to prevent anesthetic exposure to the operators

## Maintenance

Inhalation anesthesia is the method of choice for maintaining anesthesia for most prolonged procedures. Intravenous anesthetic techniques based on propofol have become more commonly employed, particularly in animals ~~of neuroprotection in concern~~ with concerns for neuroprotection, or for those procedures with limited availability of inhalational anesthesia (e.g. MRI)

### Inhalational anesthesia

- Halothane, isoflurane, sevoflurane, desflurane and nitrous oxide are available
- The advantages are patent airway, rapid control of anesthetic depth, quick and smooth recovery, and disadvantages are more pronounced cardiovascular depression including myocardial depression, hypotension, and bradycardia

### Nitrous oxide

- Analgesia from N<sub>2</sub>O reduces inhalational anesthetic requirement therefore less cardiovascular depression.
- However, the potency of nitrous oxide is only half that of human, so the sparing effect is not as obvious
- Use of this agent is not widespread in dogs

### Halothane (Fluothane®, Generics)

- 1 MAC halothane in dog is 0.8 %
- Vapor setting is at 3-4 % at induction with oxygen flow at 60 ml/kg/min and is reduced between 1-3 % during the maintenance with oxygen flow at 20 ml/kg/min

- This is no longer marketed in the US, and has been largely displaced by isoflurane
- As anesthesia is deepened by increasing halothane concentration, CO and arterial pressure decrease further. HR usually remains constant.

### Isoflurane (Aerrane®, Forane®, IsoFlo®, Generics)

- Used to be much more expensive than halothane, but now much more affordable and has replaced halothane both in human and veterinary markets worldwide
- Quicker anesthetic stabilization and more rapid recovery than halothane due to its lower blood gas solubility
- 1 MAC in dogs is 1.3%
- Vapor setting is at 3-4 % in dogs at induction with oxygen flow at 60 ml/kg/min and is reduced between 1-3 % during the maintenance with oxygen flow at 20 ml/kg/min
- Isoflurane, similar to halothane, induces a dose-dependent cardiovascular depression.
- Isoflurane causes more peripheral vasodilation than halothane, which is responsible for a low arterial blood pressure, but tissue looks more bright and pinky indicating better perfusion.
- Isoflurane is less prone to cause arrhythmia compared to halothane

### Sevoflurane (Ultane®)

- Anesthetic induction, recovery, and intraoperative modulation of anesthetic depths to be faster than halothane and isoflurane.
- More expensive than halothane and isoflurane, but it is getting less expensive.
- Sevoflurane (1 MAC = 2.3 %) is less potent than halothane or isoflurane, but more potent than desflurane
- Sevoflurane induces dose-dependent cardiovascular depression to a degree similar to that of isoflurane

### Desflurane (Suprane®)

- Lower blood/gas partition coefficient than the inhalants mentioned above, so control of anesthetic depth is the quickest among the volatile agents in clinical use
- The least potent among the volatile anesthetics (MAC = 8~11 %)
- Cardiovascular effects of desflurane are similar with those of isoflurane
- Expensive as sevoflurane, and requires electronically controlled vaporizer which adds to the inconvenience

### Total Intra-venous Anesthesia (TIVA)

- Most commonly employed TIVA is based on propofol combination ( $\pm$ opioids; benzodiazepines). The loading dose is in the order of 1-3 mg/kg as a bolus, and this is followed by 2-6 mg/kg/hr
- The recovery is very complete even following prolonged use.
- It can be used to induce anesthesia with a single bolus dose, and then to maintain anesthesia using constant rate infusion

- These combinations are associated with minimal cardiopulmonary depression. However, there are two main limitations to continued administration of intravenous anesthetics; the arterial oxygenation and prolonged recovery.
- Arterial oxygenation is always at risk with TIVA, particularly with combination of Propofol and opioids, and it is recommended the animal still be intubated and put on 100 % oxygen.
- Tight anesthetic depth control is more difficult with TIVA so abrupt awakening during anesthesia is more likely if one is not familiar with the technique and animal's physiologic reflexes unique to that (inhalant anesthetic provides advantage in this respect since monitoring anesthetic concentration in breathing gases allows better anesthetic depth control)

## Monitoring

- Anesthetic monitoring is important to maintain a proper plane of anesthesia and to prevent excessive insult to the cardiovascular, respiratory, and central nervous systems.
- Anesthetic depth can be measured by observation of the following signs: physical movement or jaw chewing in response to stimulation, eye position and degree of muscle tone, and presence or absence of palpebral reflexes etc.
- Variables used to monitor the cardiovascular system include heart rate, pulse pressure, mucous membrane color, and capillary refill time.
- Direct blood pressure measurement can provide continuous hemodynamic status of the animal and can be easily accomplished through catheterizing the dorsopedal artery.
- The ECG is useful to monitor cardiac dysrhythmias.
- The respiratory system is evaluated by monitoring respiratory rate and volume.
- It can be estimated by observing the emptying of the rebreathing bag of the anesthetic machine during respiratory cycles.
- Pulse oximetry and/or arterial blood gas analysis provide information of the ventilatory efficiency
- Ocular reflexes are used to monitor the central nervous system. The palpebral reflex may remain at moderate planes of anesthesia
- Ophthalmic ointment should be applied to the eyes during anesthesia to prevent corneal injury.
- Body temperature is also an important parameter to monitor during anesthesia. Because of the tendency for anesthetized animals to lose body heat, supplemental heat sources are often required to maintain adequate body temperature (100-102.5 °F).

## Perioperative pain management

- Opioids are mainstay analgesic used within perioperative period in the dogs.
- CNS excitement is rare unlike in cats or horses, but other side effects such as respiratory depression, vomiting and dysphoria are all possible
- Behavioral changes associated with pain include decreased appetite, aggression, indifference to the surrounding, and avoiding human contacts (see Pain notes)
- Several types of drugs have been used to provide analgesia including opioids,  $\alpha$ 2-adrenergic agonists, local anesthetics, and nonsteroidal anti-inflammatory drugs (NSAID's) of which

NSAIDs are most popular (toxicity associated with this agent is much less than in cats) (see Pain lecture).

- Multimodal analgesic therapy (e.g. morphine, ketamine, lidocaine cocktail CRI) has become more common in use to manage pain
- Significant variations exist in regards to duration of action and quality of analgesia provided by these agents.

## Recovery

- Body temperature must be maintained so as not to prolong the recovery, and lessen oxygen requirement by muscle tissues.
- Forced warm air blanket, circulating warm water blanket are very effective to keep the body temperature, but other means such as hot rice socks, used warm fluid bags, hair dryer and infra red lamps are useful external heat sources
- Endotracheal tube must remain in place until the dog regains at least a couple of strong swallowing reflexes to protect the airway, and with return of strong muscle tones. In most brachycephalics the ET tube is well tolerated and the tube can be left until they are evaluated to protect their airway on their own
- If animals pre-treated with reversible agents, recovery can be expedited by reversing the drugs with specific antagonists. Atipamezole and naloxone are two primary examples and they are best used titrated to effect. If no signs of getting light for longer than 20 minutes, reversal can be considered.
- Close observation should continue to avoid the animal relapsing into sedation which may expose the animal to potential danger of aspiration or airway obstruction

# FELINE ANESTHESIA

## Introduction

- Cats are not small dogs and their unique behavioral and physioanatomical differences make anesthesia more challenging than in dogs.
- Even very friendly cats often object to physical restraint and IV sedative/anesthetic administration in unpremedicated cats can be extremely difficult. It would, therefore, be necessary to administer good premedicants to facilitate anesthetic induction in cats.
- Behavioral alteration following general anesthesia notably due to cerebral anoxic damage as reported in men and dogs is also a possibility and owners may comment that their cat is never the same since the anesthesia
- Provided that the potential risk is recognized, suitable premedication, a smooth anesthetic induction, careful monitoring, appropriate attention to the oxygenation, ventilation and circulation will ensure a very low morbidity rate in cats.

## Preanesthetic preparation

- Starvation for about 12 hours usually ensures a cat will have an empty stomach and water need only be deprived of about 2 hours prior to anesthesia
- Laboratory evaluation can provide useful prescreening information about the general health status of the patient prior to anesthesia, and minimum database are PCV, TP, BUN and glucose
- A thorough physical examination to determine any abnormalities must be carried out. Auscultation for cardiac dysrhythmias and murmurs, or abnormal lung sounds will provide useful information regarding preexisting cardiopulmonary disease.
- Stabilize animal's physiology in debilitated animals (e.g. fluid deficit, acid-base abnormality)
- IV catheterization placement is not as easy as in dogs so heavier premedication may be required for cooperation
  - o The common site of venous catheterization is cephalic vein
  - o Other veins for venous catheter placement include the saphenous and jugular veins
  - o For jugular catheterization 16 – 18 G and 2-6 inch long catheter is suitable for most cats

## Preanesthetic agents

- A good preanesthetic sedation facilitates smooth induction and has anesthetic sparing effect during maintenance
- There are many choices available. Sedative/opioid (e.g. midazolam and hydromorphone), or dissociative/sedative (e.g. ketamine and midazolam) combinations are most popular, and they provide better restraint and analgesia than that achieved by single drug administration with less side effects (e.g. ketamine induced muscle rigidity or opioid induced mania)

## Acepromazine

- Provides mild sedation at clinically prescribed dose (0.02 – 0.1 mg/kg IV, IM, SQ)
- Anti-arrhythmic
- Requires at least 20 min for good effect even after IV injection, and 30 to 45 min when given IM, and longer for SQ
- Prolonged duration
- A young, fit cat can tolerate the premedication dose of 0.05 mg/kg with minimal cardiovascular effect
- A hypertrophic cardiomyopathy cat may benefit through decreased afterload via peripheral vasodilation, decreased myocardial oxygen consumption and increased arrhythmogenic threshold.
- However, in debilitated animals in severe cardiac failure and with decreased circulatory volume its use is contraindicated

## Diazepam/Midazolam

- When given alone, they produce no obvious sedation in cats
- They are primarily used as premedicants to counteract ketamine induced muscle rigidity and convulsions

- Because of its minimal cardiopulmonary depression, it can be a suitable premedicant for cats with underlying cardiopulmonary diseases
- 0.1 – 0.5 mg/kg IV, IM, SQ for diazepam and 0.1 to 0.3 mg/kg IV, IM, SQ for midazolam
- Diazepam is more irritant to the tissue so is recommended not to be administered IM

## Xylazine

- Doses of 0.5 - 1 mg/kg IM are used to produce mild to fairly profound sedation
- Vomiting and retching are more common at lower end of the doses
- Cardiovascular depression can be profound
- Typically used as a premedicant prior to ketamine anesthesia
- Other side effects as seen in other species also occur
  - Hyperglycemia
  - Diuresis
  - GIT motility depression
  - Platelet aggregation
- Largely displaced by medetomidine in small animals

## Medetomidine

- Causes less vomiting than xylazine
- 5-40 mcg/kg IM, SQ for cats have been given to produce mild to profound sedation. A sublingual spray at 15-30 mcg/kg can be useful to sedate an unmanageable cat. IV administration is associated with more severe form of dysrhythmias, so generally is not recommended
- Sedation lasts approximately for one hour, but can be antagonized by equal volume of atipamezole if indicated
- The pharmacologic effects of medetomidine in cats are very similar to those of xylazine
- It is important to note that increasing the dose of alpha 2 agonists does not increase the depth of sedation, but rather prolongs the duration of sedation

## Romifidine

- The most recent alpha 2 agonists
- Reduces the amount required for the anesthetic induction in dose dependent manner
- Produces dose dependent cardiovascular depression
- 10-100 mcg/kg IM, SQ

## Opioids

- When given alone, it may induce excitement so is best given with sedatives. When combined with other sedatives it provides better analgesia and sedation
- Morphine is inexpensive and is used in the dose of 0.1-0.2 mg/kg IM, SQ. This dose is much less than in dogs, but morphine is less well metabolized in cats than in dogs due to deficient

glucuronyl metabolic pathways, so, at higher doses, it is more likely to get overdosed and increases the likelihood of opioid induced excitement

- Combination of benzodiazepines with buprenorphine (or butorphanol) is a useful alternative to the combination with pure opioids for cats reducing the risk of respiratory depression
- Opioids induce minimal cardiovascular depression
- See pain lecture for other available opioids

## Anticholinergics

- Anticholinergics are used to reduce excessive salivation (particularly with use of ketamine)
- 0.02 to 0.04 mg/kg IV, IM, SQ is the recommended dose for atropine
- Atropine causes visual disturbance so cats need to be handled carefully
- Glycopyrrolate dose not cross the BBB so is preferred for cesarean section, and head trauma patients, and is less likely to develop tachycardia than atropine
- 0.005 to 0.01 mg/kg IV, IM, SQ is the recommended dose for glycopyrrolate

## Anesthetic Induction

### Ketamine

- Ketamine administered at 10 to 20 mg/kg IM produces recumbency in the cat within 3-5 minutes. Muscle rigidity and excessive salivation is not uncommon.
- A wide range of sedatives are combined with ketamine to reduce these side effects and also to reduce the amount of ketamine through a synergism
- Ketamine may cause increased heart rate, cardiac output, and blood pressure
  - o Ketamine-acepromazine
    - ▼ Acepromazine 0.02-0.1 mg/kg IM added to ketamine 10 to 20 mg/kg IM, reduces the muscle rigidity and produces status similar to general anesthesia
  - o Ketamine-medetomidine
    - ▼ Medetomidine at 10 - 50 mcg/kg added to ketamine at 5 mg/kg, produces deep sedation often recumbency. Butorphanol 0.1-0.4 mg/kg IM can be included in this combination for better analgesia, sedation and muscle relaxation.
    - ▼ Medetomidine can be substituted by xylazine 0.5 – 1.0 mg/kg, with shorter duration of sedation as xylazine has a shorter half life
  - o Ketamine-Diazepam/Midazolam
    - ▼ This combination will produce less cardiovascular depression than medetomidine-ketamine
    - ▼ Diazepam 0.25 mg/kg and ketamine 5 mg/kg given as IV bolus induces anesthesia in 1-2 minutes
    - ▼ Butorphanol 0.1-0.4 mg/kg IV can be included in this combination for better analgesia and muscle relaxation.

### Tiletamine and Zolazepam (Telazol)

- Telazol up to 4 mg/kg IV to effect or IM produces deep sedation or light anesthesia

- Side effects seen with ketamine-diazepam can be seen (emergence delirium)
- Typically used to provide deep sedation in intractable cats
- Other sedatives and opioids can be mixed to make the constituent more potent so as to increase sedation, analgesia and duration of effect, and reduce side effects (e.g. emergence delirium)

### Thiopental

- This IV injectable, barbiturate anesthetic is prepared in 1.25 % for use in cats
- Induction in unpremedicated cats can be achieved at the dose of 15 mg/kg IV given the half dose as a rapid bolus and the remaining given titrated to effect
- In lightly premedicated cats 7 mg/kg is sufficient to induce anesthetic induction
- Recovery is through redistribution of the agent from the brain into the other tissues

### Propofol

- Advantages and disadvantages of propofol for dogs as described above similarly apply to cats, but there are some unique differences
- Cats are deficient of glucuronyl transferase, so the phenolic compound is less likely to get metabolized than in dogs, and it has been shown that repeated dosing is associated with some side effects ranging from Heinz body formation, delayed recovery, anorexia, diarrhea, and malaise
- However, a single IV anesthetic induction dose will bear minimal risks
- 6 mg/kg IV is administered slowly titrated to effect to induce anesthesia, and in most premedicated cats one third to half of the calculated dose is sufficient to allow ET intubation

### Alphaxalone-Alphadolone (Saffan)

- General anesthesia can be induced by administering this steroid anesthetic
- Induction is usually smooth and rapid, but occasionally retching, vomiting and laryngeal spasm can be observed
- 9 mg/kg IV produces about 15 minute anesthesia with minimal respiratory depression and cardiovascular stability is good
- Saffan given at 18 mg/kg IM induces anesthesia in 10 minutes which effect lasts 10 to 20 minutes
- Although contraindicated for use in dogs, Saffan is a safe induction and maintenance agent in cats

### Inhalation Agents (Isoflurane, Halothane, Sevoflurane, or desflurane)

- General anesthesia can be induced by administering isoflurane, halothane, sevoflurane, or desflurane via a facemask, but a fit, unседated cat may strongly resent the attempts to force it to breathe volatile anesthetic via a face mask
- For this reason, many anesthetists prefer to induce inhalation anesthesia by placing the cat in a rectangular glass or clear plastic chamber which the cat accepts with much less struggle

- In heavily premedicated or debilitated cats, face mask induction can be carried out without excitement or struggling, and is the preferred method of choice
- The ‘incremental’ or ‘crash’ induction technique used for dogs can be adopted for cats (see above)

*Some sample doses of injectable anesthetics in the cat*

Comb. #	Premedication	Dose mg/kg	Induction agents	Dose mg/kg
1	Acepromazine ± Morphine	0.04-0.1 0.1 – 0.2	Thiopental Propofol	15 “to effect” 6 “to effect”
2	Acepromazine ± Butorphanol	0.04-0.1 0.1 – 0.4	Thiopental Propofol	15 “to effect” 6 “to effect”
3	Midazolam ± Ketamine	0.1-0.3 5	Thiopental Propofol	15 “to effect” 6 “to effect”
4	Diazepam ± Ketamine	0.1-0.4 5	Thiopental Propofol	15 “to effect” 6 “to effect”
5	Midazolam ± Hydromorphone	0.1-0.3 0.05 – 0.1	Thiopental Propofol	15 “to effect” 6 “to effect”
6	Midazolam ± Butorphanol	0.1-0.3 0.1-0.4	Thiopental Propofol	15 “to effect” 6 “to effect”
7	Medetomidine	0.005-0.04	Diazepam Ketamine	0.25 + 5 “to effect”
8	Midazolam ± Buprenorphine	0.1-0.3 0.005-0.01	Ketamine	5 “to effect”
9	Xylazine ± Butorphanol	0.5-1 0.1-0.4	Diazepam + Ketamine	0.25 + 5 “to effect”
10	Medetomidine ± Butorphanol	0.005-0.04 0.1-0.4	Thiopental Propofol	10 “to effect” 4 “to effect”
11	Midazolam ± Hydromorphone	0.1-0.3 0.05-0.2	Thiopental Propofol	15 “to effect” 6 “to effect”

## Endotracheal intubation

- The laryngeal spasm is easily provoked, so use of lidocaine spray or short acting muscle relaxant will facilitate the intubation
- In deep anesthesia laryngeal spasm does not occur, but this is not recommended as a routine procedure. However, where emergency intubation is required following accidental overdose of anesthetic, it is never necessary to use lidocaine spray or muscle relaxant
- Attempts to carry out forceful intubation through tightly apposed vocal folds, even if initially successful, will result in damage to the mucous membrane with edema and the danger of post-extubation airway obstruction

- The cat's larynx may also go into spasm after extubation, so endotracheal tubes should, if there are no surgical contraindications, be removed without any previous deliberate lightening of anesthesia and after careful aspiration of mucous from the airway
- A standard laryngoscope with an infant size blade is useful to view the laryngeal structure
- A 4.5 - 5.5 mm ET tube is suitable for most adult cats, and use of stylet can facilitate the intubation

## Maintenance

Inhalation anesthesia is the method of choice for maintaining anesthesia for most prolonged procedures. Intravenous anesthetic techniques based on Propofol has become more commonly employed, particularly in animals with concerns for neuroprotection, or for those procedures with limited availability of inhalational anesthesia (e.g. MRI)

### Inhalational anesthesia

- Halothane, isoflurane, sevoflurane, desflurane and nitrous oxide are available just as in other species.
- The advantages and disadvantages as described in dogs similarly apply in the cats (see above)

### Total Intra-venous Anesthesia (TIVA)

- TIVA combination used in dogs as described above based on propofol should still work well in cats with similar dosing. However, as described above prolonged CRI propofol has increased likelihood of toxicity in cats, and thus care must be exercised not to overdose
- Other advantages and disadvantages of this technique as applicable to the dogs are similar in the cats

## Monitoring

- Anesthetic monitoring is important to maintain a proper plane of anesthesia and to prevent excessive insult to the cardiovascular, respiratory, and central nervous systems.
- Anesthetic depth can be measured by observation of the following signs: physical movement or jaw chewing in response to stimulation, eye position and degree of muscle tone, and presence or absence of palpebral reflexes etc.
- Variables used to monitor the cardiovascular system include heart rate, pulse pressure, mucous membrane color, and capillary refill time.
- Direct blood pressure measurement can provide continuous hemodynamic status of the animal and can be easily accomplished through catheterizing the dorsopedal artery.
- The ECG is useful to monitor cardiac dysrhythmias.
- The respiratory system is evaluated by monitoring respiratory rate and volume.
- It can be estimated by observing the emptying of the rebreathing bag of the anesthetic machine during respiratory cycles.

- Pulse oximetry and/or arterial blood gas analysis provide information of the ventilatory efficiency
- Ocular reflexes are used to monitor the central nervous system. The palpebral reflex is lost at light planes of anesthesia in ruminants, so it is of little value during anesthesia of these species.
- Ophthalmic ointment should be applied to the eyes during anesthesia to prevent corneal injury.
- Body temperature is also an important parameter to monitor during anesthesia. Because of the tendency for anesthetized animals to lose body heat, supplemental heat sources are often required to maintain adequate body temperature (100-102.5°F).

## Perioperative pain management

- Traditionally use of opioids in cats within the perioperative period has not been as widespread as in dogs. However, with more research and better pharmacologic understanding, veterinarians have increased in prescribing opioids in cats
- The CNS excitement can be minimized with concurrent administration of sedatives, but other side effects such as respiratory depression, vomiting and dysphoria are still possible
- Behavioral changes associated with pain include decreased appetite, aggression, indifference to the surrounding, and avoiding human contacts (see Pain notes)
- In addition to opioids,  $\alpha$ 2-adrenergic agonists, local anesthetics, and nonsteroidal anti-inflammatory drugs (NSAID's) can be used to provide analgesia. Since cat is more susceptible to develop NSAID related toxicity, careful selection of dosing and choice of drugs is necessary to avoid complications

## Recovery

- Cats are prone to develop hypothermia during recovery due to their small size and this can significantly prolong the recovery and increase oxygen demand of the muscle tissues.
- Forced warm air blanket, circulating warm water blanket are very effective to keep the body temperature, but other means such as hot rice socks, used warm fluid bags, hair dryer and infrared lamps are useful external heat sources
- If animals pre-treated with reversible agents, recovery can be expedited by reversing the drugs with specific antagonists. Atipamezole and naloxone are two primary examples and they are best used titrated to effect. Close observation should continue to avoid the animal relapsing into sedation which may expose the animal to potential danger of aspiration or airway obstruction