Don't Let This Happen to You: Top 5 Anesthetic Complications

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Abstract: Nobody likes anesthetic complications. The most effective way to deal with anesthetic complications is to prevent them and appropriate 1) stabilization of the patient, 2) selection of type and dosage of anesthetic drugs, 3) preparation of anesthetic equipment, 4) pre-, post- and intra-operative support of the patient, and 5) physiologic monitoring, will make the anesthetic episode safer and will decrease the likelihood of anesthetic emergencies. But if we can't prevent them, we need to find rapidly find – and fix them!

Key Words: anesthesia, complications, monitoring, hypotension, hypoventilation, hypothermia

Our patient population has changed fairly dramatically in the last several decades and we are now as likely to be anesthetizing patients with some degree of compromise as to be anesthetizing patients that are perfectly healthy. This change in patient population means that we need to change the way we approach anesthesia since patients with compromise are at higher risk than healthy patients for anesthetic complications and emergencies. Patient factors that contribute to increased risk include age, presence of disease, body weight and body size.

Anesthesia causes depression of all organ systems but changes in the central nervous, cardiovascular and respiratory systems are the most immediately life-threatening. Thus, our monitoring focuses on these systems. By supporting these systems and insuring appropriate anesthetic depth, blood pressure and blood oxygen content, we provide support for all of the other organ systems. We need to be ready to and know how to respond when the patient's physiologic parameters are truly outside the normal limits. Means to correct abnormalities in blood pressure, heart rate and rhythm, and ventilation should be implemented as soon as possible to prevent deterioration of the patient.

There are many monitors available to help us provide safe and effective anesthesia for our patients. However, all monitors have advantages and disadvantages and it is extremely important to know the uses and the limitations of each monitor. It is also important to remember that there is "no safe anesthesia, only safe anesthetists" so it is extremely important that the PERSON monitoring anesthesia watch the **patient** and not rely solely on the **machine** that is displaying numbers. The machines are only as good as the person watching them and the patient will ALWAYS provide more information than the machine will provide. Thus, my favorite monitor is a **good technician/nurse!** No machine or group of machines can replace a good technician/nurse.

I. Central nervous system complications/emergencies

A. Inadequate anesthetic depth is less common and more easily fixed that excessive anesthetic depth. Prevention through diligent monitoring and appropriate use of analgesics are the keys to success.

B. Excessive anesthetic depth is the most common complication encountered in anesthesia. Excessive anesthetic depth can precipitate all of the other complications and can rapidly become an emergency rather than a complication. Unfortunately, excessive anesthetic depth

often goes unrecognized. Appropriate patient monitoring – and response to each patient as individuals – is imperative for successful anesthesia.

C. Causes of excessive anesthetic depth: Anesthetic drugs (side effects are dose dependent); age and health status of the patient (neonates, geriatrics, compromised patients require lower dosage); duration of surgery (side effects are cumulative over time); hypothermia (causes decreased need for anesthetic drugs)

D. Prevention of CNS complications/emergencies
MONITOR – continually assess anesthetic depth. Use response to surgery, eye position, jaw tone, respiratory rate and rhythm, heart rate and rhythm, arterial blood pressure, etc… and challenge the anesthetic plane by turning down the vaporizer and reassessing the patient's responses.

E. Treatment of CNS complications/emergencies
- If the patient is too deep, decrease anesthetic depth IMMEDIATELY. If necessary, turn the vaporizer completely off, fill the rebreathing bag with oxygen and ventilate for the patient.
- If the patient is too light, first assess pain management – addition of analgesia may be more appropriate than increasing the dose of anesthetic agent.

II. Respiratory complications/emergencies

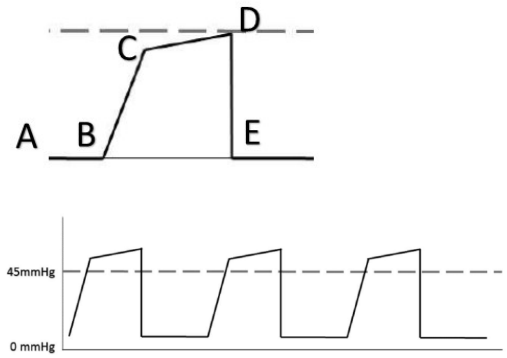
A. Hypoventilation ($PaCO_2$ or $ETCO_2$ > 55 mmHg) is the second most common anesthetic complication/emergency. However, it often occurs secondary to excessive anesthetic depth.
- Hypoventilation causes <u>hypercarbia</u> which may lead to respiratory acidosis. Hypoxemia may also occur and will lead to decreased oxygen delivery to tissues with subsequent tissue ischemia.

B. Causes of hypoventilation
Hypoventilation simply means that gas exchange (removal of CO_2/uptake of O_2) is impaired and causes of hypoventilation include anesthetic drugs, physical or physiologic issues in the patient and equipment malfunction.
- Anesthetic drugs – almost all anesthetic drugs can cause some degree of respiratory compromise. Primary offenders include propofol and inhalant anesthetic drugs. **The degree of respiratory depression is dose-dependent for most drugs and overdose of an anesthetic drug (including inhalant anesthetic drugs) is a common cause of respiratory depression.
- Physical or physiologic issues include systemic disease, CNS disease, upper airway complications and lower airway complications.
  - Systemic diseases that cause hypoventilation include any diseases that impairs CNS function (eg, septicemia) or respiratory function (eg, pneumonia).
  - Primary CNS disease, cranial trauma, brain tumors, etc… can all cause hypoventilation.
  - Upper airway complications include laryngeal dysfunction and tracheal collapse.
  - Lower airway complications include diseases (again, like pneumonia) and physiologic changes like ventilation/perfusion (V/Q) mismatch (eg, due to pulmonary consolidation or tumors, general anesthesia in horses, etc…).

- Equipment malfunction can include anything from the endotracheal tube to the oxygen supply for the hospital.
  - Common equipment problems include kinked or plugged endotracheal tubes, malfunctioning inspiratory/expiratory valves and exhausted CO_2 absorbent.

C. Hypercarbia: In conscious patients, arterial ($PaCO_2$) and end-tidal ($ETCO_2$) should be 35-45 mmHg, however, mild respiratory depression under anesthesia is acceptable and values up to 55 mmHg are tolerable.

- Hypercarbia is almost always due to hypoventilation but can also be due to
  - Failure to eliminate CO_2 due to exhausted CO_2 absorbent (rebreathing system) or inadequate air flow (non-rebreathing system)
  - Production of excessive amount of CO_2



Normal Capnograph

A-B: Zero baseline, respiratory 'pause' between breaths

B-C: Rapid, sharp rise = exhalation of mixed dead space and alveolar gas

C-D: Alveolar plateau = exhalation of mostly alveolar gas

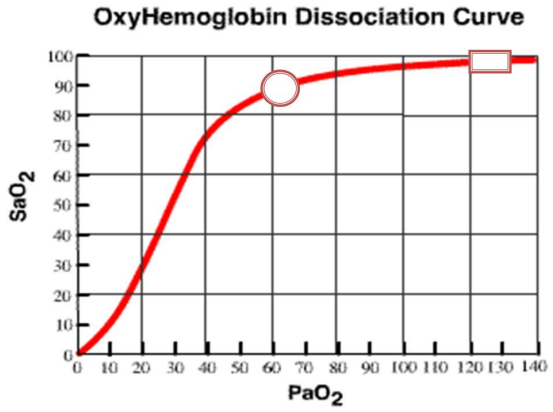
D: End-tidal value CO_2 concentration at end of exhalation

D-E: Rapid, sharp downstroke = inhalation

Capnograph indicating rebreathing of CO_2: The waveform does not return to zero baseline.

D. Hypoxemia: The ideal arterial oxygen partial pressure (PaO_2) = 5x fraction inspired oxygen [FIO_2]. True PaO_2 is rarely this high and hypoxemia is defined as PaO_2 < 50-60 mmHg on room air or <200 mmHg on 100% O_2. Hypoxemia can also be defined as oxygen saturation <90%.

- Hypoxemia can be due to
  - Hypoventilation, low FIO_2, , ventilation-perfusion mismatch, impaired diffusion of oxygen across the alveolar/arterial membrane, anatomical shunting of blood



Oxygen-hemoglobin dissociation curve, which is utilized to provide the values seen on a pulse oximeter. The circle indicates a patient on room air. Notice that hypoventilation would cause rapid desaturation (because of the steep slope of the curve). On 100% oxygen (indicated by the square), the patient is 100% saturated no matter what the oxygen partial pressure (PaO_2) is and can hypoventilate for a long time before desaturating – but that patient will likely be getting hypercarbic.

E. Hyperventilation ($PaCO_2$ or $ETCO_2$ < 25-30 mmHg) can also occur under anesthesia.

- Hyperventilation is generally due to an underlying cause like pain, inadequate anesthetic depth and elevated CO_2 (which can be caused by excessive anesthetic depth so don't automatically administer anesthetic drugs to hyperventilating patients).
- Hyperventilation can lead to respiratory alkalosis.

F. Prevention of respiratory complications/emergencies

Monitor :

- Respiratory rates (eg, 5-20 breaths/min in cats & dogs, size dependent),
- Tidal volume (10-15 ml/kg body weight)
- Mucous membrane color (pink vs 'blue'),
- Oxygen-hemoglobin saturation (SpO_2 >90-95%),
- End-tidal CO_2 (35-55 mmHg),
- Arterial blood gases

G. Treatment of respiratory complications/emergencies

QUICKLY determine the problem and FIX IT. Case: You notice that the $ETCO_2$ on the patient that you have anesthetized for an OHE is 70 mmHg and that breathing is rapid and very shallow. What do you do?

- Quickly give the patient a breath – as you are delivering the breath you are feeling for resistance in the system watching the machine and the thoracic excursion of the patient to make sure that there are no obstructions or other causes of impaired flow.
- As you are giving the breath, you are also assessing anesthetic depth, looking at the vaporizer setting and thinking about the drugs/dosages that the patient has received.
- LOOK AT THE PATIENT – not only might the cause be patient-related but sometimes electronic monitors give false information. Assess anesthetic depth, recheck the airway, etc…
- After you have made the initial assessment described above, start looking deeper. Is the CO_2 absorber exhausted? Is the $ETCO_2$ monitor functioning normally?
- If no cause can be found, change machines. Or reintubate if the tube/airway is the suspected problem.
- Finally, ask if there a cause for increased CO_2 production rather than decreased CO_2 elimination? Uncommon anesthetic emergencies like malignant hyperthermia (and anything that causes hypermetabolism) can cause an increase in CO_2 production that may overwhelm the patient's ability to eliminate CO_2.
- If no cause can be found, this patient might require ventilator assistance throughout the anesthetic episode. This is uncommon in young, healthy patients but very common in aged or compromised patients. Ventilator assistance does not necessarily mean that a mechanical ventilator is required since a person can easily ventilate for the patient. Ventilator assistance also does not necessarily mean that total control of ventilation is necessary. Many patients can breathe on their own but need some support – often 1-2 additional breaths per minute or even every 5 minutes will suffice. This will be patient dependent and appropriate support will be determined by monitoring.

III. Cardiovascular complications / emergencies

A. Hypotension (MAP<60 mmHg in small animals or <70 mmHg in horses) is the third most common anesthetic complication/emergency. As with hypoventilation, hypotension often occurs secondary to excessive anesthetic depth. Hypotension leads to decreased blood flow (and therefore decreased oxygen delivery) to the tissues.

B. Causes of hypotension

- Hypotension is generally caused by decreased cardiac output. Cardiac output is determined by heart rate (HR) x stroke volume (SV). Stroke volume is dependent on preload (circulating fluid volume), afterload (vascular tone) and myocardial contractility. Blood pressure is determined by cardiac output x systemic vascular resistance.
- Causes include anesthetic drugs and physical or physiologic issues in the patient.
    - Through effects on both HR and SV, almost all anesthetic drugs can cause some degree of cardiovascular compromise.
        - Primary offenders include propofol and inhalant anesthetic drugs. **The degree of cardiovascular depression is dose-dependent for most drugs and overdose of an anesthetic drug (including inhalant anesthetic drugs) is a common cause of cardiovascular depression.
    - Physical or physiologic issues that cause hypotension include anything that causes an impairment of pump function (myocardial contractility), vascular tone, or circulating volume.
        - Pump function can be impaired by any cardiac disease (eg, HCM, DCM, mitral insufficiency) and many systemic diseases (eg, septicemia, hypothyroidism).
        - Vascular tone is also affected by anesthetic drugs (especially inhalant drugs as they cause profound vasodilation) and systemic diseases like septicemia.
        - Circulating volume is affected by ANY form of intravascular fluid loss (eg, dehydration, hemorrhage, 'third-spacing' of fluid, evaporation of fluid from open body cavities and the respiratory tract, etc…).

C. Hypertension (MAP > 150 mmHg? – not well-defined in anesthetized animals) occasionally occurs during general anesthesia.

- Hypertension can be caused by systemic disease (eg, hyperthyroidism).
- Hypertension is generally due to an underlying cause.
    - Common causes include pain, inadequate depth of anesthesia, and hypercarbia.

D. Prevention of hypotension

Monitor:

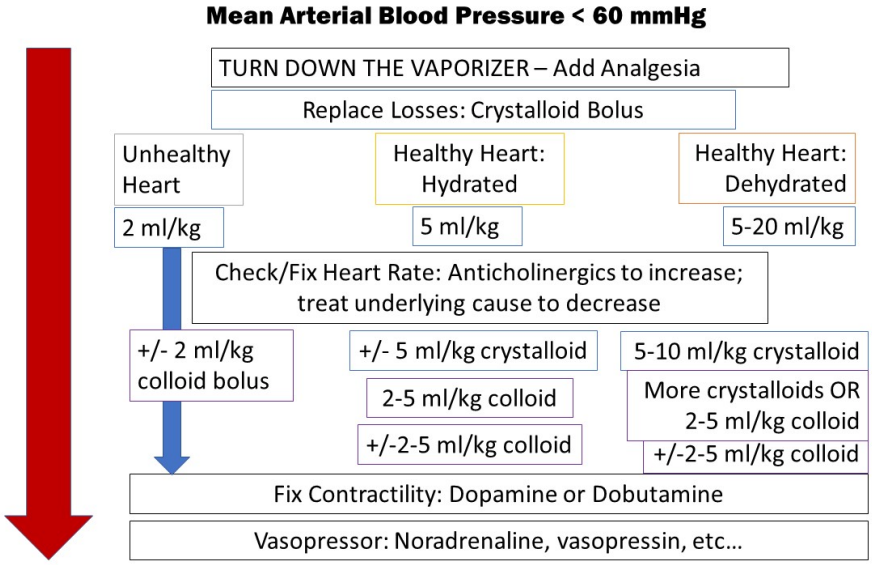
- 'Normal' heart rates should be defined as normal for the size of the patient when it is relaxed (rather than excited or scared as often occurs in patients who are being examined at the veterinary clinic). Guidelines are: 50-60 beats/min for large dogs; 60-80 beats/min for medium dogs; 80-100 beats/min for small dogs; 100-150 beats/min for extremely small dogs and for cats.
- Mucous membrane color (pink vs pale), capillary refill time (CRT<2 seconds), quality/strength of pulse.
- Arterial blood pressure (MAP >60 mmHg in small animals and 70 mmHg in horses),

- Oxygen-hemoglobin saturation (SpO_2 >90-95%). The pulse oximeter provides information not only on oxygenation but also on circulation.

E. Treatment of hypotension

Determine the problem and FIX IT.

- Hypotension – fix the pump (heart) and the fluids (and the vasculature - but the vasculature is a little harder to treat).
  - DECREASE ANESTHETIC DEPTH.
  - Increase fluid rate – give a bolus of crystalloids or colloids or both.
  - Fix the heart rate (increase or decrease).
  - Administer positive inotropic agents (eg, dopamine or dobutamine – the dose of both is roughly 1-10 microg/kg/min).



Progressively move down the flow chart until hypotension is resolved. This is a generalization of hypotension treatment for dogs. In cats, the initial fluid boluses would be 1-3 mg/kg instead of 2-5 mg/kg and 1 ml/kg colloid.

F. Arrhythmias are the fourth most common anesthetic complication/emergency.

- ANY arrhythmia can occur during anesthesia but the most commonly occurring arrhythmias are bradycardia, tachycardia and ventricular premature contractions (VPCs).
- Arrhythmias are concerning not only because they could be a result of organic cardiac disease but also because they can contribute to hypotension and decreased organ perfusion.
- Bradycardia (see normal heart rates listed under prevention)
  - May be caused by certain anesthetic drugs (eg, alpha-2 agonists, opioids and propofol) or by maneuvers that enhance vagal tone (eg, ocular or laryngeal procedures).
  - Will treat (see below) IF patient is also hypotensive and/or if there is some other concurrent arrhythmia (like second degree AV block).
- Tachycardia (see normal heart rates listed under prevention)

- Tachycardia generally occurs secondary to an underlying condition. Therefore, treatment of the underlying condition (rather than treatment of the heart rate itself) is usually the correct approach.
- Examples of underlying conditions include pain, inadequate plane of anesthesia, excessive plane of anesthesia, high CO_2, cardiac disease, systemic conditions like hyperthyroidism and septicemia, etc…

- Ventricular premature contractions (VPCs)
  - VPCs can be caused or exacerbated by pre-existing myocardial disease, by some anesthetic drugs and by physiologic abnormalities like hypoxia, hypercarbia, acidosis and electrolyte abnormalities.
  - A low number of VPCs are normal in some patients (eg, geriatric patients) and may not require treatment. Treatment should be initiated if the arrhythmia is affecting the blood pressure or if the number of VPCs is >20% of the total number of ventricular beats.

G. Prevention of arrhythmias

Monitor: ECG

H. Treatment of arrhythmias

- Bradycardia is generally vagally mediated and can be treated with anticholinergics (0.04 mg/kg atropine; 0.01mg/kg glycopyrrolate).
  - Bradycardia that is unresponsive to anticholinergics can generally be treated with catecholamines like dopamine (1-10 mg/kg/min), epinephrine (0.1-1.0 microg/kg/min) or norepinephrine (0.5-1.0 microg/kg/min).
  - Occasionally, unresponsive bradycardia may occur due to cardiac disease, toxemia, profound hypothermia, profound hypoxia, a variety of systemic diseases, etc...
  - Bradycardia should be treated anytime that the low heart rate is contributing to low blood pressure. However, remember that the alpha-2 agonists cause low heart rate with high blood pressure and using anticholinergics will cause an unnecessary increase in cardiac work.
- Generally, treat **tachycardia** by eliminating the underlying cause. (RARELY beta-blockers will be administered to patients under anesthesia to decrease tachycardia from uncommon, uncontrollable causes like pheochromocytoma.)
- The first line of treatment for **VPCs** is to eliminate all underlying causes (eg, treat electrolyte imbalances, improve oxygenation, etc…).
  - Lidocaine or procainamide should be used to treat VPCs due to myocardial disease, arrhythmias that persist after correction of the underlying cause and arrhythmias that are immediately life-threatening.
  - Lidocaine is generally the first choice for treatment of VPCs and the dose in dogs is 2-6 mg/kg IV (maximum 8 mg/kg during any 10-minute period) followed by 25-75 microg/kg/min infusion.
  - Lidocaine dose in cats is 0.2-0.5 mg/kg IV as an initial bolus followed by 10 microg/kg/min infusion.

- Procainamide dose in dogs is 10 (8-20) mg/kg IV bolus followed by 25-50 microg/kg/min infusion. The dose in cats is 1-2 mg/kg IV SLOW bolus followed by 10-20 microg/kg/min infusion.
- Procainamide can cause profound negative inotropic effects and should not be administered to patients with impaired contractility. Arterial blood pressure should be monitored during the administration of procainamide.

IV. Thermoregulation

TOP 5: #5 Tied (or maybe the winner?) with excessive anesthetic depth for most common complication.

A. *Hypothermia*: Normal body temperature: 100.5-102.5ºF (38.1-39.2ºC). The body temperature should be kept as close to normal but temperatures down to 98ºF (39.2°C) and up to 103ºF (39.7°C) can be tolerated. Hypothermia is a common complication during anesthesia & causes a variety of complications including clotting dysfunction, increased risk of infection, tissue hypoxia, acidosis, abnormal cardiac electrical conduction, myocardial ischemia, etc... (Noble 2006). Hypothermia also causes cerebral effects that decrease the patient's anesthetic needs. Unfortunately, the decreased anesthetic need is not always recognized and the delivery of anesthesia is not changed, resulting in an overdosage of anesthetic drugs. Although shivering in recovery may increase the body temperature, the intense muscle movements associated with shivering causes discomfort and increases oxygen consumption by as much as 200% (Sessler 2002). In fact, in human medicine, an active area of research centers on prevention of shivering in the postoperative period. Finally - and importantly - hypothermia is the main cause of prolonged recoveries from anesthesia. Hyperthermia is less common during anesthesia but can occur due to over-vigorous warming, drug reactions (like opioid-induced hyperthermia in cats) or as a component any disease that causes pyrexia. Malignant hyperthermia is a very rare genetic condition.

B. *Causes of hypothermia*: Anesthesia induced vasodilation, muscle relaxation and decreased thermoregulatory control. Cold tables and rooms. Cold scrub solution and excessive patient wetting. Cold oxygen flowing through the airways. ANESTHESIA TIME.

C. *Prevention of hypothermia*

MONITOR: Continuous monitoring is ideal but intermittent monitoring is acceptable. Core temperature as measured by an esophageal temperature probe is generally more accurate than rectal temperature (because feces is often present in the rectum).

D. *Treatment of hypothermia*: Use active warming in all anesthetized patients. Forced air blankets tend to be most effective. The biggest drop in temperature occurs right at/after induction as anesthetic drugs cause vasodilatory heat loss and the thermoregulatory center becomes less responsive to body temperature changes. Start warming right at induction. Small body-size patients suffer the worst heat loss and body temperature support should be 'aggressive' in these patients.

E. *For hyperthermia*, remove all heating devices and start actively cooling the patient with fans, cool water, etc… To avoid making the patient hypothermic, stop active cooling when the

patient's body temperature reaches 103°F (39.7°C).

Summary:
The 'best defense is a good offense' game plan is highly appropriate for anesthesia. By carefully monitoring anesthetized patients, we can quickly recognize negative trends in patient parameters and make appropriate changes to keep the patient from deteriorating. Changes in CNS, cardiovascular and respiratory systems are the most immediately life threatening, thus, our monitoring is focused on these systems. All practices should be monitoring anesthetic depth, mucous membrane color, capillary refill time, heart rate and rhythm, pulse quality, respiratory rate and rhythm, and blood pressure. To maximize anesthetic success, we should adopt the words of the musician Sting (of The Police) as our anesthetic mantra: 'every breath you take, every move you make, I'll be watching you'.

Further Reading and More Information: Grubb T, Sager J, Gaynor JS, Montgomery E, Parker JA, Shafford H, Tearney C. 2020 AAHA Anesthesia and Monitoring Guidelines for Dogs and Cats. J Am Anim Hosp Assoc 2020;56(2):59-82. https://pubmed.ncbi.nlm.nih.gov/32078360/

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Sedation and Anesthesia for Fractious Patients

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Abstract: Patients may be fractious because of underlying behavioral problems or situational responses to stress, like a visit to the veterinary clinic. These patients can be a danger to humans trying to handle them and to themselves with a strong stress response and need for high doses of sedative drugs. The safest way to deal with these patients is to be proactive from the beginning with anxiolytics administered at home and appropriate sedation on arrival at the clinic.

Key Words: sedation, anesthesia, fractious, aggressive, pain, anxiolytics

Start Treatment at Home

Ideally, treatment of the anxious/fractious/aggressive patient should start at home before the patient leaves its house or yard. A calm patient is easier and safer to anesthetize. The dose of drugs needed to sedate/anesthetize patients escalates as anxiety/fractiousness/aggression escalates and, since the adverse effects of most sedative/anesthetic drugs are dose-dependent, this can lead to a dangerous potential for drug overdose.

The cause of the anxiety/fractiousness/aggression should be determined, if possible, as some causes potentially require more extensive treatment for the pet's benefit (eg, behavioral modification). Fear and anxiety commonly cause fractiousness and aggression, as does pain. Fear/anxiety can exacerbate pain and pain – and the anticipation of pain – can exacerbate fear/anxiety. Some patients may be highly fractious/aggressive and require sedation at home. Thus, treatment at home may mean long-term therapy (eg, SNRIs or benzodiazepines for fear & anxiety and/or NSAIDs and/or other analgesic drugs for chronic pain) AND/OR immediate therapy the day before and day of the veterinary visit (eg, trazodone, gabapentin, sedatives, opioids, etc…).

Trazodone and gabapentin have wide safety margins and are effective for calming most dogs and cats prior to their veterinary clinic visit. Although either species could have either drug, trazodone seems to be most effective for dogs and gabapentin seems to be most effective for cats. In cats, the gabapentin dose is 50-200 mg/cat (not per kg) depending on the size of the cat and the fear/fractiousness level. The dose for dogs is 10-20 (up to 40) mg/kg. Trazodone is dosed at 5-7 mg/kg in dogs (up to 15 mg/kg if aggressive – this is much higher than the dose used to change behavior – this is just to get the dog in the clinic) and 50-100 mg/cat (not per kg) in cats. The two can be combined in patients with high anxiety/fractiousness or aggression.

A single dose the morning of travel to the veterinary visit is sufficient for many patients, but if the patient has moderate-high anxiety/stress/fear or is fractious or aggressive, the most effective

protocol is to administer a dose of the drug the night before the veterinary visit and again the morning of the veterinary visit at least two hours before the trigger that indicates that the patient is leaving home (getting the carrier out, grabbing the car keys, etc…). Both drugs can cause some sedation, which is a benefit in this situation. For pre-hospital visit administration, the dose of both drugs is generally higher than that used for long-term calming or treatment of chronic pain (gabapentin only). In those instances, sedation is not usually the goal. As with all sedatives, these drugs can cause ataxia in older or weak patients. Paradoxical excitement has been reported for both drugs but is extremely uncommon and not seen by the author. Diarrhea has also been reported, as with most drugs administered PO.

Dosages for all drugs are in a table at the end of the notes. For patients that need deeper sedation, acepromazine can be added to the protocol and can be used in the specific 'Chill Protocol' that includes not only acepromazine but also gabapentin and melatonin). Transmucosal (Sileo®) or oral alpha-2 agonists might also be beneficial. Longer term treatment with benzodiazepines (eg, lorazepam) may be required in some patients. Short acting benzodiazepines (eg, diazepam) administered immediately prior to the visit may cause paradoxical excitement and are not recommended. Again, pain should also be treated. Gabapentin plays a role in pain relief so it can serve two roles. NSAIDs, oral opioids and other drugs should be considered, depending on the source of pain and patient health.

Ensure pain is managed prior to the visit if possible. Pain can cause high FAS (fear/anxiety/stress) and high FAS can exacerbate the level of pain.

NOTE: A small piece of cheese, meat, peanut butter, etc…. to make the drugs more palatable is totally acceptable and the benefits of the drugs outweigh the fear of 'something in the stomach' at anesthesia time. All patients should be treated as though they have 'something in the stomach' and should be induced and intubated rapidly. Also, fasting times for patients are shorter now than they were in the past with roughly 6 hours likely adequate in most patients.

At the Hospital

Once in the hospital, the patient should spend minimal (or no) time in noisy lobbies, should be placed in a quiet exam room, and should be handled by veterinarians/technicians/staff with appropriate training and compassion for the behavior status of the animal. The use of pheromones, music and other calming techniques may also benefit the patient.

COMMON QUESTIONS: *Do I sedate the patient in the hospital if it had pre-visit calming drugs/sedatives? If so, how do I determine the sedative dose?*

The answer depends on both what the patient is in the hospital for and the compliance level of the patient. If in the hospital for anesthesia, the answer is YES! SEDATE! And add preemptive analgesic drugs (usually opioids). Premedicant sedatives and analgesics make anesthesia safer by

allowing a decrease in the dose of anesthetic drugs required to maintain unconsciousness. Adverse effects of anesthetic drugs are generally dose-dependent. My guideline: If the patient is as sedate as a patient who has in-hospital premeds, administer the analgesic drug only; if the patient is obviously sedate but still a little nervous/reactive, administer ¼ of the usual premedicant sedative dose + full dose of opioid; if the patient clearly has some sedation but not enough to easily handle the patient, administer ½ of the usual premedicant sedative dose + full opioid dose; if the patient is showing no signs of sedation, administer the full dose of the premedicant sedative + full opioid dose. This may prolong recovery, but this can be controlled if reversible sedatives are administered.

If the patient is not necessarily in the hospital for anesthesia, we can gently and briefly 'ask' the patient if it needs more sedation. When it is time to examine or treat the patient, gentle handling may be sufficient if the patient has mild fear/anxiety or pain or even moderate fear/anxiety or pain that has responded to therapy at home. DON'T BE AFRAID TO SEDATE THE PATIENT and DON'T WAIT UNTIL THE SITUATION HAS IRREVOCABLY ESCALATED if the patient is showing signs of moderate-severe anxiety or fear or any level of fractiousness/aggression. This is dangerous for everyone, including the patient, and early use of sedatives/analgesics can prevent a bad situation. If the situation has already escalated beyond what can be controlled by sedation/analgesia, consider either proceeding with general anesthesia immediately (even if no exam has been done) or rescheduling the appointment. If reschedule is not possible, skip to the anesthetic section of the notes – ketamine or Telazol should be used as part of the protocol at this point.

Sedative/analgesic/anesthetic drugs

Drugs, and more importantly the drug dosages (Table 2), for sedation/anesthesia/analgesia are chosen based on the patient's degree of fear/anxiety or aggression, level of pain, and sedation/anesthesia risk level (ASA Status, Table 1). The anticipated degree of restraint required, invasiveness of the procedure that the pet is at the hospital for and degree of pain that will be caused by the procedure are also considerations. There is no 'one size fits all' in these situations. 'Appropriate drugs' and 'appropriate dosages' will be very patient and situation dependent and the protocols presented here are guidelines, but each veterinarian should choose individualized protocols using their clinical experience.

IMPORTANT POINT TO REMEMBER: Response to drugs can be quite varied in patients with fear/anxiety, fractiousness/aggression and/or pain. Expect an unpredictable response – especially in unpredictable patients – and be ready to escalate your protocol – or to send the patient home and try another day.

Alpha-2 adrenergic agonists (eg, Dexdomitor®)

- Advantages: provide analgesia, effects are reversible, can provide anything from light to deep sedation, can be administered IM, onset of action is rapid, oral mucosal absorption does occur and injectable drug can be squirted directly into the patient's mouth or Sileo® can be administered, anxiolytic
- Disadvantages: cause cardiovascular changes that are well-tolerated in patients with healthy hearts but are not appropriate for patients with cardiovascular disease. When a physical exam is not possible due to the patient's level of fear or aggression, the concern for alpha-2 agonist effects on the cardiovascular system should be weighed against the reality of the effects of the patient's behavior (eg, lunging, fighting, running) on the cardiovascular system. Often a dose of an alpha-2 agonist is warranted in these situations.
- TIPS: 1) Even if the patient is not painful, administer the alpha-2 agonist with an opioid for deeper, more predictable levels of sedation; 2) After injection, let the patient 'rest' in a quiet room without attempting to examine the patient for approximately 20 minutes. The onset of the drug is slower in excited/fearful patients; 3) Expect that the peak level of sedation in excited/fearful patients will be lower than in calm patients so be prepared to go to the next step (eg, anesthesia) if necessary; 4) In aggressive patients, start with the full label dose of the alpha-2 agonist (with an opioid) – one injection is likely all that is achievable without further stressing the patient and 5) AGE IS NOT A DISEASE. Not sure where the rule 'patients >7 years of age should not get alpha-2 agonists' came from, but it is totally incorrect. Base that decision on comorbidities, not on age. If the patient can't be examined, sedation is <u>required</u> or nothing can be done with the patient. Warn the owner that the pet is at increased risk for adverse effects since a full physical exam cannot be done and proceed with sedation.

Opioids

- Morphine, hydromorphone, methadone, oxymorphone, fentanyl, butorphanol, buprenorphine
- Advantages: provide moderate to profound analgesia, are reversible
- Disadvantages: may not provide enough sedation when used alone in young, healthy or excited patients
- NOTE: Butorphanol is a good sedative but provides only short-duration analgesia (60 minutes in the dog; 90 minutes in the cat)
- Both buprenorphine (dogs and cats) and methadone (maybe just cats?) are absorbed from the oral mucosa.

Acepromazine

- Advantages: Inexpensive, mild to moderate sedation, long-lasting (appropriate for long-term calming), some transmucosal absorption (ie, injectable acepromazine squirted in the mouth or mixed with food like peanut butter or squirt cheese for the patient to lick up), oral tablets are available and work for some patients.
- Disadvantages: No analgesia, may not be potent enough to sedate fearful/fractious patients when used alone, definitely not potent enough to sedate aggressive patients

when used alone, long-lasting (not desired if the patient is too sedate to be safely discharged), not anxiolytic.

- NOTE: The liquid acepromazine is a fairly common addition to pre-visit protocols in patients that do not have an adequate response to gabapentin and/or trazodone.

Benzodiazepines - Diazepam (Valium®) and Midazolam (Versed®)

- Advantages: minimal to no adverse effects, reversible, anxiolytic
- Disadvantages: generally don't provide adequate sedation when used alone in young, healthy or excited patients, no analgesia. Can cause paradoxical excitement.

Next Step: Add an anesthetic drug

If it is clear that the patient is not manageable without anesthesia, this may be the first step rather than the next step. The most common drug class for this step is the dissociative class, ie, ketamine or Telazol. Both of these drugs can be administered IM and provide profound sedation or anesthesia, depending on the dose. Obviously, if the patient is manageable, any injectable anesthetic drug could be administered IV. THIS IS NOW ANESTHESIA! Physiologic monitoring and support should be provided.

Ketamine

- Advantages: inexpensive, can be administered IM, rarely mild respiratory depression, no cardiovascular depression (unless the patient has uncontrolled heart failure – in which case they are unlikely to have the energy that would lead to the need for this technique).
- Disadvantages - very poor anesthesia and no muscle relaxation when use alone - must be combined with a sedative such as valium, medetomidine or dexmedetomidine, mild to moderate sting on injection.
- TIP: Adding IM ketamine to a protocol can be used at a high dose to provide full anesthesia (eg, the Dexmedetomidine, opioid, ketamine combination often used in cats) or can be used in a lower dose to decrease patient reactivity (‘ketamine stun’). In medium to large dogs the volume of ketamine needed to provide full anesthesia is likely too large to quickly inject so the ketamine stun technique will be more useful.
- Ketamine stun dose: 1-2 mg/kg added to the sedative, administered IM.
- Absorbed when squirted on the oral mucosa: Use the full label dose since some will be ‘lost’.

Telazol®

- Advantages: potent, rapid induction, can be administered IM; other advantages same as ketamine.
- Disadvantages: recoveries can be prolonged and rough (especially in dogs), thus a sedative should always be used in conjunction with Telazol®; other disadvantages same as ketamine.
- TIP: A small volume of Telazol® will provide full anesthesia even in large dogs. This is my drug of choice for aggressive patients.

- Absorbed when squirted on the oral mucosa: Use the full label dose since some will be 'lost'.
- Telazol powder can be reconstituted with dexmedetomidine and butorphanol (called 'TTDex') instead of with sterile water or saline. See information from Dr. Jeff Ko for dosing chart. http://www.aapma.com/resources/TTDex%20Injectable%20Chart%26Micro-dose.pdf
- NOTE: The butorphanol in the TTDex protocol provides minimal analgesia so be sure to add analgesic drugs!

Telazol-Torbugesic-Dexdomitor (TTDex) Injectable Chart

TTDex = Combine 2.5mL Dexmedetomidine (500 mcg/mL) and 2.5mL Butorphanol (10 mg/mL) with 1 bottle (500 mg) of Telazol powder.

Lbs	Kg	Mild Sedation 0.005ml/kg	Moderate Sedation 0.01ml/kg	Profound Sedation 0.02ml/kg	Surgical Anesthesia 0.035ml/kg	Profound Surgical Anesthesia 0.04ml/kg
2-4	1-2	0.005 ml	0.01 ml	0.02 ml	0.035 mL	0.04 ml
4-7	2-3	0.013 ml	0.025 ml	0.05 ml	0.09 ml	0.12 ml
7-9	3-4	0.018 ml	0.035 ml	0.07 ml	0.12 ml	0.15 ml
9-11	4-5	0.023 ml	0.045 ml	0.09 ml	0.16 ml	0.19 ml
11-22	5-10	0.038 ml	0.075 ml	0.15 ml	0.26 ml	0.37 ml
22-29	10-13	0.06 ml	0.12 ml	0.24 ml	0.40 ml	0.48 ml
29-33	13-15	0.07 ml	0.14 ml	0.28 ml	0.49 ml	0.58 ml
33-44	15-20	0.09 ml	0.18 ml	0.36 ml	0.61 ml	0.78 ml

Portion of Dr. Ko's TKD chart

Recovery from Anesthesia

Once the procedure is complete the patient should be allowed to recover in a quiet area and should be discharged as soon as safely possible. In some patients, reversal drugs may be appropriate to speed recovery but remember that fast recovery may mean bad recovery. If at all possible, patients should be allowed to recover quietly without reversal. Reversal drugs can always be administered just before the patient leaves – even in the owner's car if necessary. Ensure that the patient is conscious enough to not be dangerous to the owner (ie, not reactive to stimuli that would not normally cause a reaction in the pet). Pain should be addressed prior to reversal and patients that have undergone painful procedures should be discharged with analgesic drugs. The patient should be discharged patient with calming drugs/anxiolytics/sedatives (eg, trazodone or gabapentin +/- acepromazine; perhaps dexmedetomidine gel) to be administered at home prior to the next hospital visit.

TABLE: Sedative, Analgesic and Anesthetic Drugs. Not all of the drugs or drug dosages in this chart are licensed/approved for use in dogs and cats. However, all of the dosages in this chart are commonly used and can be referenced in the veterinary literature. A variety of drugs/protocols are available, choices should be made based on the veterinarian's experience and drug availability. Drugs are presented in alphabetical order in each category. PO= per os or oral , OTM = oral transmucosal membrane or buccal, FAS = fractious/anxious/stressed. **DOSAGES in mg/kg unless otherwise indicated.**

DRUG & DOSAGE (mg/kg – unless otherwise indicated)	**ADVANTAGES**	**DISADVANTAGES/ CONCERNS**	**NOTES**
Drugs to Administer at Home			
Acepromazine **Dog** & **Cat:** 0.025-0.05 OTM	Inexpensive, this is common injectable acepromazine	Effects are somewhat variable	Effects are variable, but much less variable than oral tables. See below for Chill Protocol
Benzodiazepines (all PO) **Cat:** Alprazolam 0.125-0.25 or lorazepam 0.25-0.5 mg/cat **Dog:** Alprazolam 0.02-0.1, Diazepam 0.5-0.2, Lorazepam 0.02-0.1	True anxiolytics	Can cause paradoxical excitement in some patients	Great choice for anxiety, generally not potent enough for aggressive or extreme FAS; may need extra dose night prior to hospital visit
Clonidine PO **Dog** & **Cat:** 0.01 to 0.05	Oral alpha-2 agonist	Bradycardia	Little to no information for using in this context
Dexmedetomidine gel (OTM) **Dog:** 0.01-0.04 **Cat:** 0.02 (**one dot** on the syringe barrel)	Effective for mild calming at low dosages, more sedation at higher dosages	Unlikely to be potent enough for aggressive patients unless the dose is increased	Licensed for noise phobia, not fractiousness and aggression. Not approved for cats, but used in cats. Administer 30-60 minutes prior to leaving home
Diphenhydramine?			Effects are highly variable
Gabapentin PO **Dog:**10-20 (up to 40) **Cat:** 50-200 mg/cat	Wide safety margin	No major concern. Cleared in part by the kidney so potentially more profound effect in CATS with renal disease. More likely to occur with repeat dosing for chronic pain	Effective for calming, mild to moderate sedation, mild analgesia. Administer at least 2 hrs prior to leaving home, may need extra dose night prior to hospital visit. Dogs have primarily hepatic clearance so renal disease not a concern.
Trazodone PO **Dog:** 5-7 (up to 15 if aggressive); **Cat:** 50-100 mg/cat	Wide safety margin	No major concerns	Effective for calming, mild to moderate sedation. Administer at least 2 hrs prior to leaving home, may need extra dose night prior to hospital visit

Melatonin PO* Small **dogs and cats** 0.5-1 mg; med dogs 1-3 mg; large dogs 5mg	*Note dosing is mg per patient not mg/kg		Administer at least 2 hrs prior to leaving home, may need extra dose night prior to hospital visit
Chill Protocol Gabapentin PO (20-25 mg/kg **dogs** or 50-200/**cat**) and melatonin* PO (dosages listed above); Acepromazine injectable formulation (0.025-0.05 OTM **dogs & cats**)	Wide safety margin, very effective *Note melatonin dosing is mg per patient not mg/kg	No major concerns	Gabapentin & melatonin the night before & morning of (2 hours prior to leaving home) hospital visit; acepromazine 30 minutes before leaving home. *Costa RS, Karas AZ, Borns-Weil S. Clinicians Brief. May 2019.*
Sedative/Analgesic Drugs for In-Hospital Use (primarily IV or IM dosing)			
ACEPROMAZINE **Dog:** 0.01-0.03 IV or IM (up to 0.2 IM) **Cat:** 0.03- 0.05 (up to 0.2 IM) Can be used alone but best used in combination with opioids and/or other sedatives. Can use **OTM** as described in previous section	Mild to moderate sedation for several hours; can be given orally or OTM but higher doses will be required & onset of effects are slow	Not anxiolytic, analgesic or reversible; duration may be longer than desired	If anxiolysis rather than sedation is required, a benzodiazepine should be added to the protocol. No absolute contraindications but use with caution in patients with hepatic disease, clotting dysfunction, or hypotension; recent evidence proves that ace does NOT cause seizures.
ALFAXALONE **Cat and small dog**: 0.5-1.0 IM	Mild to moderate sedation for 20-40 minutes. More predictable effects if combined with an opioid or benzodiazepine	Mild dose-dependent cardiovascular & respiratory depression	Alfaxalone is an anesthetic induction drug that can be used IM for sedation. It is best used with opioids and in cats & small dogs since the injectate volume can be very large for medium-large patients.
ALPHA-2 AGONISTS *Dexmedetomidine* **For light to moderate sedation**: **Dog:**0.001-0.003 IV or 0.003-0.01 IM; **Cat:**0.001-0.005 IV or 0.005-0.015 IM **For deeper sedation:** **Dog:**0.008-0.03 IV or 0.01-0.04 IM **Cat:**0.02-0.04 IM **OTM dosing:** **Dog:** 0.01-0.03 **Cat:** 0.015-0.04	Provide analgesia & sedation; effects are reversible rapid onset; titratable sedation from mild to profound; decreased stress as evidenced by decreased cortisol release. In dogs, 0.2 mg/kg OTM	Cardiovascular effects including bradycardia, hypertension and increased cardiac work due to vasoconstriction; sudden, brief arousal can occur with painful stimulus – alleviated by concurrent opioid	Generally the most effective drugs for patients exhibiting moderate to profound FAS or aggression; most predictable effects when used in combination with opioids. Can reverse drug effects once procedure is complete and patient is in a calm, quiet area where restraint is possible if needed.

Use low end of dosing range if used in conjunction with opioids or other sedatives, for older patients & patients with low level of fear/anxiety; Use high end of range if used alone, for younger patients and patients with higher level of fear/anxiety or aggression. *Medetomidine* Dosages are roughly double the mg/kg dexmedetomidine dosages.	dexmedetomidine provided similar effects to 0.005 mg/kg IV (Dent et al. Am J Vet Res. 2019;80(10):969-975)	administration. Vomiting, especially if administered SQ. Excessive salivation, vomiting and bradycardia are fairly common with OTM administration.	Contraindication: do not use in patients with cardiovascular disease.
MEDETOMIDINE + VATINOXAN I dose roughly the same as medetomidine. Label dose is higher	Similar to other alpha-2 agonists.	Less/no vasoconstriction so no less bradycardia (no reflex bradycardia). Lower intraop BP when compared to other alpha-2s – treatable with dopamine.	Slightly faster onset, slightly shorter duration of action when compared to medetomidine without the vatinoxan. Used as premed (off-label) or for procedural sedation in dogs. Not approved in cats.
BENZODIAZEPINES *Midazolam* **Dog or Cat:** 0.1 -0.2 **IM** or IV *Diazepam* **Dog or Cat:** 0.1-0.2 IV only	Minimal to no adverse effects; enhance calming when used in combination with sedatives	Sedation is minimal; may not be effective if patient is already exhibiting FAS or aggression and paradoxical excitement can occur if used alone!	Never use alone in these patients. Use with an opioid and/or true sedative for those exhibiting FAS and/or aggression. Be cautious with reversal as it may cause sudden arousal. Generally no need to reverse effects.
OPIOIDS: Low Pain *Butorphanol* **Dog & Cat:** 0.2-0.4 IM or IV *Buprenorphine* **Dog & Cat:** 0.02-0.03 IM or IV 0.03-0.05 OTM (slow onset)	Opioids provide mild to potent analgesia depending on the drug & dose and have a wide safety margin; fast onset except buprenorphine (10-30 mins); reversible; many to choose from; variety of routes of administration; synergistic with sedatives	May cause vomiting, slow GI motility and some respiratory depression if used with other respiratory depressing drugs (eg, inhalants); more potent opioids may cause excitement and/or hyperthermia in cats	Combine with a sedative; with mild pain can use butorphanol or buprenorphine; with moderate to severe pain use hydromorphone, methadone, morphine or oxymorphone. No contraindications but use with caution in patients in which vomiting or slowed GI motility would be detrimental.
OPIOIDS: High Pain *Hydromorphone:* **Dog:**0.1-0.2 IM, IV; **Cat:**0.1 IM, IV *Methadone:* **Dog:** 0.3-0.5 IM or IV; **Cat:** 0.3 IM or IV; **0.6 OTM**			

Morphine: **Dog:** 0.3-1.0 IM **Cat**: 0.1-0.3 IM			Ref OTM methadone cat: *Ferreira et al. Am J Vet Res. 2011 Jun;72(6):764-71.*
Anesthetic Drugs Any anesthetic drugs can be used if IV access is available. Listed here are drugs that can also be used IM and/or OTM.			
KETAMINE **Dog & Cat:** 1.0-2.0 IM when used in combination with a sedative may provide dissociation without anesthesia while the same dose IV will provide light anesthesia. 5.0-10.0 mg/kg IM for true anesthesia; IM is a good for route for cats but the volume at this dose may be too high for medium-large dogs **OTM Dog & Cat**: 5-10 **TILETAMINE-ZOLAZEPAM** **Dog & Cat:**1.0-2.0 IM or IV can be added to sedatives/opioids for light to moderate sedation For anesthesia WITH PREMEDS: **Dogs:**5-6 IM; 2-3 IV **Cats:** 6-8 IM; 2-3 IV **Dogs & Cats:** 5-7.5 OTM *(Cat study: Nejamkin P et al. J Feline Med Surg. 2020;22(2):108-113)*	Decrease CNS response to circulating neurotransmitters in those already exhibiting FAS and/or aggression; decrease incidence of sudden arousal to stimulus; ketamine (and maybe tiletamine) can contribute to pain relief.	Duration and/or depth may be longer and/or more profound than desired; ketamine & tiletamine are not reversible; ketamine is painful on injection; prolonged, rough recoveries are possible with tiletamine-zolazepam, especially in dogs.	This is anesthesia so patients should be monitored! There are no absolute contraindications but use with caution in patients with sympathetically driven cardiac arrhythmias and those with clinically significant hepatic or renal disease since these drugs are cleared by the liver & kidneys. For OTM, the most consistent effect is achieved if the ketamine is combined with the OTM alpha-2 agonist. Telazol can be used with or without the alpha-2 agonist with fairly consistent effects. Telazol has been used in meat-balls delivered **orally** to dogs at 20 mg/kg + 2 mg/kg acepromazine. In the same study, pentobarbital (63.2 +/- 5.1 mg/kg) was also effective in meatballs *(Ramsay & Wetzel, JAVMA 1998;213(2):240-2).*

Whisker of Truth: Fact & Fiction Anesthesia & Analgesia in Cats

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Abstract: The statement that cats are not small dogs applies not only to life, but also anesthesia & analgesia. The differences between cats and dogs may not be large, but they can have a large impact if cat-specific anesthesia/analgesia concerns are not addressed.

Key Words: cat, feline, anxiety, pain, anesthesia, analgesia

Cats Facts

- Often nervous or fractious: Increased circulating catecholamines and increased Fear/Anxiety/Stress (FAS) = Increased dose of anesthetic drugs required
- Small body size: May be difficult to dose, to fit to monitoring & anesthetic equipment & to keep warm
- Species-specific drug metabolism: May not metabolize drugs the same as dogs do (eg, NSAIDs): Species-specific response to drugs; may respond differently than dogs do (eg, opioids sometimes)

These differences add to the fact that cats are at higher risk than dogs for anesthesia-related deaths (risk factor of 0.11% vs 0.05%, respectively, in healthy patients and 1.33% vs 1.4%, respectively; Brodbelt 2009).

Preanesthesia

As with other species, patients should be stabilized prior to anesthesia and premedication should be utilized to improve the safety of anesthesia by allowing a decrease in the dosages of induction and maintenance drugs. Anxiolytics are often very helpful to decrease FAS.

Common Previsit Pharmaceuticals

Gabapentin	100-200 mg/cat 2 hours before leaving home +/- night before leaving home
Trazodone	50-100 mg/cat, same timing as gabapentin, can administer with gabapentin

Maropitant	1-2 mg/kg orally 2 hours before leaving home, nausea/vomiting can cause FAS

Preoperative drugs or drug classes and key cat points:

Opioids	Excellent choice for all cats. Moderate to profound analgesia, minimal adverse effects, reversible effects. Many drug and delivery options. Cat specific opioids: Simbadol® (24-hr duration) & Zorbium® (4-day duration, transdermal).
Alpha-2 Agonists	Excellent choice for many cats. Mild to profound sedation with analgesia. Effects are reversible. Contraindicated in some forms of cardiovascular disease but may be beneficial in left ventricular outflow tract obstruction because of decreased heart rate. Causes emesis, prevent with maropitant.
Acepromazine	Often a good choice. Provides 4-8 hours of light to moderate sedation, which is a benefit, especially for many hospitalized cats. No analgesia, effects not reversible.
Benzodiazepines	Minimal adverse effects, minimal sedation in young, active patients. Can be effective, especially when combined with an opioid, in very young/very old/sick cats. Midazolam would be the most likely benzo to be used as a premed since it can be administered IM. Anxiolytic☺.
Ketamine	Often administered IM as part of an anesthetic protocol – so not really a premed but administered concurrently with premeds (usually dexmedetomidine and an opioid).
Alfaxalone	Can be used at a low dose (0.5-2.0 mg/kg) IM for moderate sedation of 20-45 mins in very young/old or sick cats (in general, not enough sedation for healthy or excited cats). Better sedation when combined with an opioid.

Cat facts vs myths & misconceptions for the premedication phase of anesthesia

Opioids can cause hyperthermia in cats The hyperthermia is usually – but not always - mild and self-limiting. Body temperature should be monitored postoperatively and any cat that seems agitated in recovery should be checked for hyperthermia. There is evidence that the degree of hyperthermia may be related to the degree of HYPO-thermia during the maintenance phase of anesthesia.

- Full opioid agonists (bind to mu and kappa) receptors are slightly more likely to cause excitement in cats than in dogs. Combine with a sedative to decrease excitement.
- Buprenorphine and butorphanol are unlikely to cause excitement but are less potent (especially butorphanol) than full mu agonists.
- Butorphanol only lasts about 90 minutes in the cat (Lascelles BD, Roberston SA. AJVR 2004;65(8):1085-1089); buprenorphine lasts 4-6 (MAYBE 8 with mild pain) hours.
- Oral transmucosally (OTM) administered buprenorphine results in lower serum concentrations of the drug. Increase the dosing range to 0.01-0.05 mg/kg BID-TID.
- Simbadol® is buprenorphine in a higher concentration (1.8 mg/ml) than 'regular' buprenorphine that is FDA-approved for cats. It is labeled for subcutaneous administration (regular buprenorphine is very poorly absorbed after SQ administration) that provides analgesia for 24-hours. It is a DEA Class III drug, just like regular buprenorphine (which is not FDA-approved in animals).
- Zorbium® is buprenorphine that was just approved by the FDA for cats. It provides 4 days of analgesia following transdermal administration. DEA Class III.
- Dexmedetomidine is also FDA-approved for use in cats. Alpha-2 agonists provide analgesia and a range of sedation levels (depending on the dose), can be administered IM and the effects are reversible with atipamezole. If you aren't using alpha-2 agonists in cats, you are missing out on a great drug class.
- Alpha-2 agonist mediated vasoconstriction causes increased cardiac work, which is why these drugs are contraindicated in many types of cardiovascular disease. However, the slowed heart rate can be beneficial in relieving left ventricular outflow tract obstruction (Lamont et al. JAVMA 2002;221(9):1276-81).
- Alpha-2 agonist mediated bradycardia is a reflex that occurs secondary to vasoconstriction mediated hypertension. This allows decreased cardiac work and is a beneficial reflex. Don't increase the heart rate unless the patient is bradycardic AND hypotensive.
- Should NSAIDs be administered to cats as premedications? Cats have pain of inflammation. Both meloxicam and robenacoxib are approved for preoperative use in cats and NSAIDs are generally most effective if used preemptively. However, NAIDs block the prostaglandin effect of vasodilation that occurs in some organs (eg, kidneys)

during states of low-flow. Cats seem to be more likely than dogs to suffer NSAID-related adverse renal effects so administration of NSAIDs postoperatively, after turning off the inhalant so hypotension is unlikely, is also a good option.

Induction drugs and key cat points

Propofol	Can easily be titrated 'to effect'. Cleared by multiple routes. Causes mild to moderate dose-dependent cardiovascular and respiratory depression. Can be administered with a benzodiazepine or ketamine ('ketafol') to decrease propofol dose. IV only.
Alfaxalone	Can easily be titrated 'to effect'. Causes mild to moderate dose-dependent cardiovascular and respiratory depression. Can be administered with a benzodiazepine to decrease alfaxalone dose. Can be administered IM or IV.
Ketamine	Can be administered IM or IV. Minimal to no respiratory changes, provides mild to moderate increase in heart rate and blood pressure (through stimulation of the sympathetic nervous system). Cleared in part unchanged in the urine. MIGHT contribute to sympathetically-driven arrhythmias? No muscle relaxation, administer with a benzodiazepine or alpha-2 agonist. CRI for analgesia.
Tiletamine/ Zolazepam	Physiologic effects similar to ketamine/benzodiazepine. Very potent, small volumes easy to dose – and to overdose if not careful.
Inhalants	Not the safest choice for induction. Dose is very high – increases risk for anesthesia-related death. Staff are exposed to gases so human health concerns as well as cat health concerns.

Cat facts vs myths & misconceptions for induction drugs

- Propofol can be safely used in cats with hepatic lipidosis (Posner LP, et al. JAVMA 2008;232(12):1841-3), even though propofol itself is a lipid.
- The preservative in the 'newer' propofol (Propoflo28) is NOT toxic to cats (Taylor PM, et al. J Feline Med Surg 2012;14(8):516-26). This type of propofol is preferred to the old propofol because the preservative allows the bottle to be used for 28 days after opening whereas the old propofol without a preservative could only be used for 6 hours after opening. This propofol CAN BE USED IN CATS! It isn't FDA approve in cats, but most drugs aren't☹.
- Alfaxalone is an excellent option in cats for both sedation and induction. It causes dose-dependent cardiovascular and respiratory depression similar to that of propofol but absorption after IM administration is an advantage in cats and small dogs.
- KETAMINE IS NOT CONTRAINDICATED IN ANY CAT BREED (eg, Savannah or Maine Coons). The presence of cardiac disease, which these breeds may be more prone to, could maybe be a contraindication – but not the breed. Because of their traditionally high anxiety, these breeds often benefit from a 'ketamine stun' dose added to premeds. Ketamine infusions are extremely low-dose and not a concern even with cardiac disease.
- Inhalant induction (mask or chamber induction) is a risk factor for anesthesia-related death and should NOT be the routine method of induction to anesthesia in cats (Brodbelt 2009).

Cat specific information on intubation:

- Intubate carefully (not cat-specific but cats are more difficult to intubate than most dogs).
- Apply a drop of lidocaine on each arytenoid. Cats are more prone than dogs to laryngospasm. Lidocaine reduces the likelihood of laryngospasm. Lidocaine does not cause adverse effects – cetacaine does.
- If still difficult to intubate, administer more induction drug. Don't intubate an awake cat.

- Inserting an endotracheal tube was a risk factor for anesthesia-related death in cats (Brodbelt 2009) – but it isn't the tube that is a risk factor, it is poor intubation that is risky.
- Laryngeal mask airways are an excellent option for cats. They are easy to place, do not damage the airway and come in a variety of sizes.
- Disconnect patients from breathing systems before repositioning them – especially cats. The twisting of the tube in the trachea as the patient is repositioned can cause tracheal damage.
- Don't use a rigid mouth gag for intubation (or for dentistry, or anything else) in cats. These mouth gags cause excessive opening of the mouth which can cause occlusion of the maxillary artery, which is the main source of blood supply to the retina and brain in cats (Martin-Flores M, et al. Vet J 2014;200:60-64). Occlusion of this artery secondary to mouth gag use has been linked to blindness and neurologic dysfunction, some of which led to euthanasia (Stiles J, et al. Vet J 2012: 2012;193(2): 367-73).

Cat facts vs myths & misconceptions for the maintenance phase of anesthesia

- As with other species, inhalant anesthetic drugs are commonly used for procedures lasting > 30 mins. Nothing cat specific.
- Injectable drugs are also commonly used in cats for short procedures. These are often administered IM since really small cat veins can make IV injection difficult. Common protocols include:
    - Ketamine + an opioid + an alpha-2 agonist
        - Common combination: 0.1-0.2 MLS per 4.5 kg of cat of the following 3 drugs: dexmedetomidine, ketamine, buprenorphine (or 10 mg/ml butorphanol). Combine all 3 drugs in same syringe and administer IM. Use low-end of dose for deep sedation and high-end for anesthesia. Increase or decrease the dose if cat is larger/smaller than roughly 4.5 kg. This combination ('kitty magic') takes effect in 5-10 mins and provides 20-30 mins of anesthesia.
    - Tiletamine/zolazepam alone (not ideal – no sedation or analgesia)
    - Tiletamine/zolazepam opioid + an alpha-2 agonist

        - Common combination: Reconstitute the Telazol with 2.5 mls butorphanol (10 mg/ml) and 2.5 mls ketamine (sometimes called 'TTDex'). Dose the combination at 0.005 mls/kg for mild sedation, 0.01 ml/kg for moderate sedation, 0.02 ml/kg for profound sedation and 0.035-0.04 ml/kg for surgical anesthesia (Ko and Berman. Top Comp Anim Med 2010;25(2):92-97.
- Analgesia
    - To decrease the dose-dependent impact on cardiovascular and respiratory function, keep the inhalant DOSE LOW! The best way to do that is to use analgesia. Use opioids, local blocks and infusions. Lidocaine infusions are controversial in cats but lidocaine -or any other local anesthetic – used as a locoregional block is very effective.

Monitors/Monitoring & key cat points

ECG	Can be hard to detect the **small complexes**. Increase the tracing amplitude.
Blood pressure - oscillometric	Can be hard to get a reading. Blood pressure is the same as in the dog, but the **small vessels** can be hard to detect. Be sure that the cuff is not too large (cuff width should be approximately 40% of limb/tail circumference) and positioned over the largest artery possible. The cuff should fit snugly on the limb. Too big or too loose = falsely low BP. Same comment on MAP vs SAP as described for the Doppler.
Blood pressure - Doppler	Usually the best way to get a blood pressure reading in really small patients. Systolic blood pressure as determined by the Doppler **may be closer to MAP than SAP in cats** (Caulkett et al. Vet Surg 1998;27:370-377). Author note: **Assume it as systolic and carefully assess the cat.** Treat if necessary.
SpO_2	Great! But cats are very likely to get cold (small body size) and **vasoconstriction** decreases likelihood of getting a reading. Reposition the probe to an area of better blood flow (eg, base of tongue). But first check the patient and make sure it is breathing normally!

ET CO_2	**Sidestream may provide average CO_2 rather than true end-tidal** reading in patients with small tidal volumes and high respiratory. rate. Can use an adapter that extends down into the ET tube to increase accuracy.

- Support

  Be careful with fluids!

  - Administration of fluids was listed as a risk factor for anesthesia-related death (Brodbelt 2009). But it isn't the fluid – it is the amount of fluid - that kill cats.
  - Calculate – and administer – the volume of fluids very carefully. Best to draw up the desired amount in a syringe vs trying to deliver a small volume from a fluid bag. Can also use rate-limiting tools like syringe pump or burette.
- Cats are very likely to be hypothermic – be aggressive with warming - & monitor body temperature
  - Prevention is easier than rewarming. Temperature starts dropping AT INDUCTION
  - Forced air blanket most effective
  - Warm patient's environment - Surgery room, recovery cage, etc…
  - Use warm fluids, warm scrub solution (and MINIMAL scrub solution), warm lavage solution, etc…
  - **Minimize anesthesia time.**

Cat facts vs myths & misconceptions for the recovery phase of anesthesia

Most unexpected anesthetic deaths occur in recovery (Brodbelt D, Vet J 2009;182:152-161).

Timing of Death	**% of cats that died (number of cats)**
After Premedication	1% (14)
Induction	8% (53)
Maintenance	30% (30)
Recovery	61% (106)
0-3 hours after Recovery	66 total cats

- Continue monitoring and supporting the patients until they are safely awake. Make sure cats are warm – but not hyperthermic.
- Also need to address pain and dysphoria. A rough recovery is not acceptable as it can lead to injury, high FAS and can contribute to hyperthermia. Think pain first and re-dose the opioids. May need to include a sedative. Alpha-2 agonists are excellent because they provide both sedation AND analgesia.
- Of course, we can also reverse the effects of the reversible drugs if necessary – but be sure to address analgesia! There are numerous myths regarding atipamezole in cats. Atipamezole at ½-full volume of dexmedetomidine (0.5 mg/ml) IM or very slowly IV. Readdress analgesia even when using a lower volume as a full reversal can still occur depending on how much of the drug has been metabolized.
- Discharge drugs: NSAIDs, buprenorphine, maybe gabapentin or other drugs. Long duration buprenorphine (24-hr injectable and 4-day transdermal) should be considered to decrease care-giver burden and ensure cat gets its medications.

Further Reading

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Anesthesia and Analgesia for Patients with Comorbidities

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Abstract: Our veterinary patient population has changed as our medical skills have progressed and we have become capable of supporting patients with advanced disease and/or advancing age. All tranquilizers, induction drugs and inhalant drugs cause CNS depression and most cause some degree of dose-dependent physiologic dysfunction. In healthy patients, many of the physiologic effects of anesthetic drugs are tolerated or can be counteracted by routine measures such as administration of oxygen or intravenous (IV) fluids. In compromised patients, these effects can be quite dangerous as they may magnify pre-existing disease-related physiologic dysfunction. Patient needs should be addressed in each of the 4 distinct and equally important periods: 1) preparation /premedication; 2) induction; 3) maintenance and 4) recovery. In healthy patients, many of the physiologic effects of anesthetic drugs are tolerated or can be counteracted by routine measures such as administration of oxygen or intravenous (IV) fluids. In compromised patients, these effects can be exacerbated, further contributing to the demise of the patient. Successful anesthesia in compromised patients is highly dependent on adequate patient stabilization, diligent patient support and monitoring, and the use of appropriate anesthetic drugs at appropriate **dosages.**

Key Words: anesthesia, analgesia, comorbidity, stabilization, monitoring, oxygen delivery

Preparation for Anesthesia & Premedications

Stabilization of critical or challenging patients prior to sedation and/or anesthesia is imperative. Both increasing American Society of Anesthesiologists (ASA) scores and increasing urgency of the procedure increase risk of anesthetic death (Brodbelt 2009).

Analgesia should be part of stabilization. Pain creates a tremendous sympatho-adrenal stress response and can contribute to **morbidity** and perhaps even **mortality**. Relief of pain can provide hemodynamic and respiratory stabilization, along with many other positive benefits. If relieving pain does **not** provide stabilization, the veterinarian will know to rapidly continue diagnostics as something other than pain is the main cause of the patient's condition. Safe, reversible drugs like the opioids are excellent choices for most challenging patients. When possible, decreased fear/anxiety/stress (FAS) should also be part of stabilization as FAS can often exacerbate the negative components of underlying disease through the FAS-induced stress response and can increase pain intensity. Drugs like gabapentin, trazodone and alfaxalone are generally safe and often administered to hospitalized patients if not administered before the patient left home.

Oxygen delivery. Most critical patients have disease or conditions that cause at least some degree of cardiovascular and/or respiratory compromise, potentially resulting in decreased tissue oxygen delivery. Many anesthetics also cause at least some degree of cardiovascular and respiratory compromise, also potentially resulting in decreased tissue oxygen delivery. One of the critical roles of the anesthetist is to support oxygen delivery by promoting normal function in both the cardiovascular and respiratory systems. Monitoring of those systems may need to start prior to induction in some patients.

Equipment. Both anesthesia delivery and anesthesia support/monitoring equipment should be checked and rechecked to insure they are working properly. The anesthesia machine and breathing system become part of the patient's airway when connected to the endotracheal tube. So any equipment malfunction = patient malfunction.

Sedatives / tranquilizers: Although not intuitive that critical patients need premedicants, the use of premedicants will decrease the dose of induction and maintenance anesthetic drugs. Since adverse effects are dose dependent, decreasing the dosages will improve anesthetic safety.

- *Opioids - morphine, fentanyl, methadone, butorphanol, buprenorphine:* Advantages: Provide moderate to profound analgesia, minimal to no cardiovascular effects, minimal respiratory effects, allow a decrease in dosage of maintenance drugs, reversible, many are inexpensive, provide sedation, versatile (can be administered PO, IM, IV, SQ, in the epidural space, in the intra-articular space, etc...). Disadvantages*:* cause vomiting (administer maropitant), relatively short duration of action when compared to the duration of most pain (administer as an infusion).
- *Benzodiazepines – Diazepam, midazolam:* Advantages: Wide safety margin, minimal to no cardiovascular or respiratory effects, reversible. Excellent choice for critical patients – either as a premed or a part of induction. Disadvantages: Minimal to no sedation when used alone in healthy patients and can cause paradoxical excitement, especially in stressed or fractious patients, no analgesia.
- *Alfaxalone* – Advantages: Can provide dose-dependent light to moderate sedation and can be administered IM or IV. Disadvantages: Some dose-dependent cardiovascular & respiratory effects – VERY minor at the sedative dose, volume limited to small patients, can cause 'rough' recoveries – unlikely at the sedative dose, no analgesia.
- *Acepromazine* – not commonly used in compromised/challenging patients (the exception is patients with upper airway compromise that need long-term sedation and some patients with cardiovascular disease that would benefit from a reduction in afterload). Disadvantages: not reversible, causes vasodilation which could contribute to hypotension in compromised patients.
- *Alpha-2 agonists* – not commonly used in compromised patients because they rarely need profound sedation but appropriate in stable emergency patients that need sedation/analgesia.

Advantages: Provide both sedation and analgesia, effects are reversible. Disadvantages: Causes increased cardiac work.

Other drugs: Maropitant is recommended, both for its anti-emetic effects and its potential for contributing to analgesia. Vomiting itself, with the intense contraction of abdominal muscles, is painful. This can greatly exacerbate the pain level in patients with pre-existing abdominal pain. Disease-specific drugs might also be necessary, as an example, a lidocaine infusion could be necessary in patients with ventricular tachyarrhythmias.

Other tasks: As mentioned, monitoring prior to induction is recommended in patients with comorbidities, depending on which comorbidity and how severe. PREOXYGENATE! Takes only 3 minutes to fully saturate hemoglobin with oxygen, which decreases the time of patient desaturation from 1 minute (patient on room air) to 5 minutes. Great support of oxygen delivery!

Induction

- *Propofol:* Advantages: rapid induction and recovery, easy to titrate 'to effect', multiple routes of clearance from the body, good muscle relaxation. Disadvantages: Causes mild to moderate dose-dependent respiratory and cardiovascular depression
- *Alfaxalone:* Advantages: rapid induction and recovery, easy to titrate 'to effect'. Disadvantages: Causes mild to moderate dose-dependent respiratory and cardiovascular depression. Can cause rough recoveries, uncommon in appropriately sedated patients.
- *Ketamine:* Advantages: inexpensive, can be administered IM, mild respiratory depression, no cardiovascular depression in heart-healthy patients. Disadvantages: can cause cardiovascular depression in patients with cardiovascular compromise, can cause muscle rigidity.
- *Etomidate*: Advantages: no cardiovascular effects. Disadvantages*:* expensive, poor muscle relaxation, vocalization, maybe not appropriate in septic patients due to adrenocortical suppression.
- ***Inhalant induction is NOT appropriate*** *for almost all dogs and cats.* The dose of the inhalant is entirely too high when used alone (side effects of inhalants are dose-dependent) and the induction will be stressful and will be prolonged. Furthermore, use of inhalants alone for induction and maintenance increases the risk of anesthesia-related death (Brodbelt 2009).

REMINDER: All tranquilizers, induction drugs and inhalant drugs cause CNS depression and most cause some degree of **dose-dependent** respiratory and cardiovascular dysfunction. **All drugs should be dosed 'to effect'**. In many comorbidities, the circulation becomes centralized so a larger percentage of the drug dose gets to the brain, thus decreasing the dose the patient would need for induction when compared to a healthy patient. Also, in many comorbidities,

cardiac output is decreased so the time it takes for the induction drug to get to the brain is increased. So give a LOW dose and wait longer to see the effect than you would wait in a healthy patient. Repeat the mantra: “Low and slow”.

Maintenance

Low-dose inhalant anesthesia is generally the most logical way to maintain anesthesia that will last 30 minutes or more since inhalants don’t have to be metabolized for the patient to regain consciousness. However, inhalant anesthetic drugs should never be used as the sole anesthetic drug since inhalants can cause significant hypotension and hypoventilation. Our goal should always be to keep the vaporizer setting as low as possible. Often, *analgesia* must be provided in order to minimize *anesthesia* drug doses. *Advantages*: easy to administer, relatively inexpensive, are eliminated with minimal metabolism. *Disadvantages*: DOSE DEPENDENT contribution to hypoventilation, hypotension and hypothermia. MONITOR, MONITOR, MONITOR. **NOTE:** The advantages and disadvantages of the inhalant drugs are class effects and apply to all inhalants. However, sevoflurane has an advantage in critical patients since it is more easily dosed ‘to effect’ because of its lower solubility coefficient.

Analgesic Drugs & Techniques

Maintenance of anesthesia is much easier and safer if analgesia is provided prior to the painful stimulus. Most anesthetic drugs, including the anesthetic gases, block the brain's perception that pain has occurred but don't actually block pain. If pain is severe enough, the brain can still respond and make the patient appear to be inadequately anesthetized. This usually leads to an increased inhalant dose and the brain ceases to respond, but the patient is now too deeply anesthetized and can be at a very dangerous physiologic plane. A more appropriate response would be to block the pain and maintain anesthesia at a light, safe depth. The advantage to all of the drugs and techniques listed below is that they are anesthetic-sparing, meaning that they allow a decrease in the anesthetic dose necessary to maintain unconsciousness.

- *Opioids:* Advantages: provide moderate to profound analgesia, cause minimal cardiovascular or respiratory effects, are reversible. Disadvantages: Previously discussed opioid-meditated adverse effects.
- *Local anesthetic drugs & locoregional techniques:* Advantages: Inexpensive, easy to administer, very effective. Drugs block the pain impulse from getting to the dorsal horn of the spinal cord and thus decrease the incidence of central sensitization. This results in pain that is much lower, not only during the block, but even beyond the expected duration of the drug itself. Local blockade also decreases the likelihood that chronic pain will develop secondary to the acute pain. Disadvantages: Relatively short duration of action when compared to the duration of pain, except for NOCITA®.

  NOTE: Local anesthetics are underutilized, yet they are easy to use, inexpensive and highly effective.

- *Constant rate infusions (CRIs):* Advantages: EASY, inexpensive, effective, many drug choices (opioids, lidocaine, ketamine, alpha-2 agonists and combinations). Disadvantages: Almost none because of the low dose delivered but side effects from any drug could always occur. There is a very useful open-access CRI calculator at IVAPM.org under the 'professionals' tab.

Monitoring & Support

Monitoring: Anesthesia causes changes in all organ systems but the changes in the CNS, cardiovascular and respiratory systems are the most immediately life-threatening so monitoring and support is focused on these systems. Also, support of these systems will provide support for other systems by providing adequate oxygen delivery to the organs/tissues of that system. Don't forget the basics: mucous color, capillary refill time, jaw tone, eye position, etc… Utilize SpO_2 (pulse oximeter) and end-tidal CO_2 to assess respiratory function. Utilize ECG and **blood pressure** to assess cardiovascular function. Measurement of blood pressure is IMPERATIVE in critical patients.

Cardiovascular support includes use of IV fluids & positive inotropic and antiarrhythmic drugs.

- *IV fluids* should be used, as needed, to rehydrate the patient and replace ongoing losses. Do not overhydrate – excessive administration of fluids can cause edema.
- Many critical patients would benefit from the use of *colloids* in addition to crystalloids. Voluven (Vetstarch) is commonly used and the total dose in the dog is $\leq$50 ml/kg in a 24-hour period. Cats should generally receive $\leq$30-40 ml/kg in a 24-hour period.
- If patients have hemorrhaged, if severe hemorrhage is expected intraoperatively or if the patient is anemic (PCV < 18-20%), collect blood for a *blood transfusion* prior to anesthesia.
- Oxygen bound to hemoglobin is the main source of oxygen delivered to the tissues. If the patient is hypoproteinemic (albumin <2 g/dl), administer *plasma* prior to anesthesia.
- If the patient is hypotensive:
    1. If anesthetized, TURN DOWN THE VAPORIZER.
    2. Give boluses of fluids (5-10 ml/kg rapidly) or colloids (5 ml/kg rapidly).
    3. Consider positive inotropes like dopamine or dobutamine. Dose of each is 1-10 microg/kg/min (up to 15 with dopamine). Patients with conditions that cause decreased cardiac contractility (eg, sepsis, etc…) are likely to need positive inotropes for effective blood pressure support.
    4. If these measures are not effective or if the patient is severely vasodilated, vasopressors (eg, norepinephrine, vasopressin) may be necessary.

Respiratory support includes oxygen delivery and maintenance of ventilation.

- Oxygen is inexpensive and profoundly beneficial in many critical patients. When in doubt, administer oxygen!

- If the patient is having any trouble ventilating (head trauma, thoracic trauma, profound CNS depression, impingement on thorax by GI contents, etc…) ADMINISTER OXYGEN.
- If the ventilatory depression is moderate, consider intubation. If severe, INTUBATE.
- Obviously most anesthetized patients would be intubated. Intubate rapidly and quickly inflate the endotracheal tube cuff to an appropriate pressure.
- Many compromised patients will require assisted ventilation because the respiratory drive in-response to hypoxemia and/or hypercarbia may be impaired and/or the patient may not physically be able to ventilate normally (muscle weakness, thoracic trauma, electrolyte imbalance, GI distension, etc…). Assisted ventilation: 2 breaths/min to 15-20 cmH_2O on the manometer. Controlled ventilation: 6-10 breaths/min to 15-20 cm H_2O on the manometer. If a ventilator is available, set tidal volume to 15-20 ml/kg. MONITOR End-tidal CO_2 – normal is 35-55 mmHg in the anesthetized patient (35-45 mmHg in conscious patients); Do not over ventilate.

Hypothermia

Adverse effects of hypothermia

- Decreased need for anesthetic drugs
- PROLONGED RECOVERY from anesthesia
- Impaired metabolism (adds to prolonged recovery)
- Immune system depression
- Coagulation dysfunction, sludging of blood
- Decreased cardiac contractility, arrhythmias
- Respiratory impairment
- Increased oxygen consumption (shivering)
- Etc…

- **START WARMING AT INDUCTION, MINIMIZE ANESTHESIA TIME**

Recovery

Unfortunately, most anesthetic deaths occur in recovery and the majority of those occur within the first 3 hours of recovery (Brodbelt 2009). The cause is likely a decrease in anesthetist vigilance in recovery. Support and monitoring should be continued into the recovery phase, especially for challenging patients. Analgesia should also be re-addressed. If effective analgesia is utilized pre- and intra-operatively, the analgesic needs of the patient may be minimal. Opioid boluses and constant rate infusions are excellent choices during the recovery period. NSAIDs may be appropriate depending on the disease. The drugs diminish pain at its source (inflammation) making them very powerful. Administer NSAIDS if not contra-indicated.

Specific examples

Patient with cardiovascular disease/dysfunction

The cardiovascular system includes the heart, blood vessels and blood/plasma. Thus, cardiovascular disease or dysfunction encompasses `conditions ranging from decreased cardiac contractility to arrhythmias to anemia. Diseases that are not necessarily cardiovascular diseases but which affect the cardiovascular system (eg, hyperthyroidism, sepsis, etc…) should also be considered in this category when making anesthetic plans for patients with those diseases. In addition, anesthetic drugs (e.g. inhalants), perioperative manipulations (e.g. recumbency, positive pressure ventilation) and surgical complications (e.g. uncontrolled pain, hemorrhage) can exacerbate cardiovascular dysfunction – and can even cause cardiovascular changes that mimic cardiovascular disease. Thus, a fair number of anesthetized patients may need cardiovascular support, even in the absence of cardiovascular disease. Because of the vast number of diseases/conditions that affect the cardiovascular system, one anesthetic protocol may not be appropriate for all patients in this category, but an understanding of cardiovascular physiology and the cardiovascular effects of the anesthetic drugs will promote appropriate anesthetic/analgesic protocol selection. In addition to appropriate dose/drug selection, diligent patient monitoring and support are crucial.

Physiology of the Cardiovascular System & Anesthesia Goals

The ultimate goal of the cardiovascular system is to work in concert with the respiratory system to provide adequate oxygen delivery (DO_2) to the working cells. The cardiovascular system's role in this goal is achieved through support of cardiac output, which is a product of heart rate (HR) and stroke volume (SV). Stroke volume is determined by preload, afterload and myocardial contractility (inotropy). In all patients, the focus should be on support of normal physiologic processes in order to optimize tissue oxygen delivery.

Preanesthetic preparation

STABILIZE the patient! Long term if possible (eg, send home on drugs that improve cardiac function) or short term in not possible (eg, administer fast-acting anti-arrhythmic drugs to treat arrhythmias). However, drugs that may decrease blood pressure (eg, beta-blockers, calcium channel blockers) should be withheld on the morning of anesthesia. Once ready for anesthesia, preoxygenate to decrease the likelihood of decreased oxygen delivery. Start on JUDICIOUS rate of IV fluids if the patient is hypovolemic at a suggested rate of 2-5 ml/kg/hr depending on the disease and patient. Monitors should be connected to the patient prior to induction. Numerous physiologic changes can happen at induction. Warming should start now since body temperature starts to drop at induction. Hypothermia causes adverse cardiovascular effects like decreased myocardial contractility, arrhythmias and bradycardia.

Excitement, struggling and fear cause tachycardia and increased peripheral resistance, arterial blood pressure, cardiac work and cardiac oxygen consumption. These changes are generally well-tolerated in patients with a healthy cardiovascular system but are extremely dangerous in a patient with cardiovascular disease, possibly resulting in decompensation and cardiac failure. Pain causes the same sympathetic response as excitement, struggling and fear. Therefore, all of

these stressors must be avoided in patients with cardiovascular disease and calm handling, along with the administration of a low-dose of a tranquilizer and preemptive analgesic drug, are crucial. **Opioids** have minimal adverse impact on the cardiovascular system and are the drug class of choice for patients with cardiovascular disease.

Disease-specific comments

Hypertrophic cardiomyopathy (mostly cats) and dilatative cardiomyopathy/regurgitant valvular disease (mostly dogs) have different physiologic impacts and, thus, different anesthetic concerns.

- Hypertrophic cardiomyopathy: In this disease the cardiac muscle is overworked so avoid drugs that further increase cardiac work (through increased rate or contractility). Increased work will increase myocardial oxygen need - but the hypertrophic cardiac muscle is generally not matched by increased vasculature, thus oxygen delivery can be decreased. This could include ketamine (no concern at CRI dose), anticholinergics, etc… Inotropes are somewhat controversial as some clinicians feel that they are contraindicated but research shows they are safe and effective when used at low dosages. Both dopamine and phenylephrine improved blood pressure but only dopamine improved cardiac output. (Wiese et al 2012). Slower heart rates (allow time for ventricles to fill) and vasoconstriction (increased afterload which can decrease left ventricular outflow obstruction) is often beneficial in these patients, thus alpha-2 agonists may be considered (Lamont et al. 2002) if needed to adequately control the cat (Lamont et al. 2002).
- Dilatative cardiomyopathy/regurgitant valvular disease: In this disease the cardiac muscle is inefficient for appropriate ejection of adequate blood volume or the dysfunctional valve promotes inadequate ejection blood volume. In these patients, the goal is myocardial contractility support and decreased ejection resistance (ie, vasodilation). Low-dose acepromazine may be beneficial. Ketamine can be very useful as it increases both rate and contractility through SNS stimulation. Increased heart rate may be necessary so anticholinergics may be indicated. Inotropes are beneficial.

Preanesthetic drugs: Specific cardiovascular (CV) effects/concerns

Opioids	Minimal CV effects – no change in contractility, some vagally-mediated bradycardia; 'cardio sparing'
Alpha-2 Agonists	Increased cardiac work from vasoconstriction. Generally contraindicated, but may be beneficial in some diseases[2]
Acepromazine	Low dose = decreased afterload but high dose = hypotension
Benzodiazepines	No CV effects; Cardio sparing; Not very sedating – combine with an opioid

Preoxygenate: Decreases the likelihood of decreased oxygen delivery. Preoxygenation for only 3 minutes increases the time do desaturation (SpO2<90%) approximately 1 minute to 6 minutes.

Induction drugs: Specific cardiovascular effects/concerns

Propofol	Mild to moderate dose-dependent cardiovascular (CV) depression.[3] Administer premeds to decrease the dose of induction drug required to produce anesthesia.
Alfaxalone	Mild to moderate dose-dependent CV depression.[3] Administer premeds to decrease the dose of induction drug required to produce anesthesia.
Ketamine	Increased HR & contractility through SNS in healthy hearts but direct myocardial depression in uncompensated heart failure; MAY exacerbate tachyarrhythmias? CRI dose is not concerning.
Telazol	Probably same effects as ketamine.
Etomidate	Minimal to no impact on CV system. Drug of choice for profound disease.
Inhalants	Moderate to profound dose-dependent CV depression. Don't induce with inhalants!

TIP: Administer a low-dose benzodiazepine or fentanyl bolus just before induction to decrease the dose of induction drug.

Maintenance

Inhalants can cause hypotension since they cause both dose-dependent decreased cardiac contractility and vasodilation. KEEP THE DOSE LOW. Add **analgesia**! Opioid boluses, local blocks and infusions of opioids, lidocaine and/or ketamine are all good options. Ketamine at the infusion dose used for infusions is unlikely to cause adverse effects and is commonly used for patients with cardiac disease.

Monitoring: Blood pressure, ECG, SpO_2 and $ETCO_2$. Need to monitor both the respiratory and cardiovascular systems to insure oxygen delivery.

Support: Maintain MAP >8 kPa (>60 mmHg). The steps to promote normotension are:

- DECREASE the INHALANT DOSE
- **Support cardiovascular function with inotropes**
    - Dopamine, dobutamine
    - In a patient with myocardial disease/dysfunction, decreased contractility is the most likely cause of hypotension so start inotropes early.
- Check the heart rate – fix if necessary
- JUDICIOUS use of IV fluids if hypovolemia is present
    - 2-10 ml/kg/hr intra-op
    - Balanced electrolyte solution
    - Blood or plasma if necessary
- USE COLLOIDS – eg, hetastarch
- Treat arrhythmias appropriately
    - Arrhythmias can affect cardiac output

Recovery
DON'T STOP MONITORING and SUPPORT
The more compromised the patient, the longer monitoring and support should continue.
Keep warm. Shivering can increase oxygen consumption by up to 200%, which may not be met by oxygen delivery in patients with cardiovascular disease.
Readdress analgesia; USE TRANQUILIZERS if necessary – DON'T allow a rough recovery! The stress physiologic stress can exacerbate cardiac dysfunction. NSAIDs if appropriate: No negative CV effects, Anti-inflammatory

Sample Protocol
Preanesthesia: Physical exam, complete blood work, thoracic radiographs, ECG. Consider maropitant.
Premedication: Opioid IM (unless catheter already placed); preoxygenate if possible
If the patient is really sick, skip the IM premed and use fentanyl IV at induction.
Induction: 0.2 mg/kg midazolam or diazepam IV followed by propofol, alfaxalone or etomidate SLOWLY to effect. Fentanyl (2-5 microg/kg) can be substituted for or added to the benzodiazepine.
Maintenance: LOW DOSE inhalant; use CRIs (especially fentanyl or other opioid) & local blocks. Monitor ECG and blood pressure; use dopamine CRI for hypotension; use active warming.
Recovery: Keep monitoring until patient is fully awake; Provide analgesia with opioids
Administer NSAIDs if there are no contraindications.

Resources
Grubb T, Sager J, Gaynor JS, Montgomery E, Parker JA, Shafford H, Tearney C. 2020 AAHA Anesthesia and Monitoring Guidelines for Dogs and Cats. J Am Anim Hosp Assoc. 2020 Mar/Apr;56(2):59-82. https://www.aaha.org/aaha-guidelines/2020-aaha-anesthesia-and-monitoring-guidelines-for-dogs-and-cats/anesthesia-and-monitoring-home/

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SHOULD I BE CONCERNED ABOUT VACCINE SAFETY?

NEW FINDINGS ABOUT COMPANION ANIMAL VACCINE SAFETY

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Abstract:

Keywords: reaction, adverse, immune, vaccination

Evaluation of benefit and risk of vaccination is a central theme of discussions regarding companion animal vaccination. Although successful vaccination programs have markedly reduced the incidence of infectious diseases, society has also decreased its tolerance for any undesirable outcomes from the practice of modern medicine. Harmful or undesirable health events can be temporally associated with vaccination without being causally related. Nevertheless, vaccine-associated adverse events (VAAE) are of particular concern to practitioners, animal owners, and vaccine manufacturers, because vaccines are generally administered to healthy animals and the medical dictum is to "first do no harm".

Factors known to cause vaccine reactions include the primary vaccine agent or antigen, adjuvants, preservatives, stabilizers, and residues from tissue cultures used in vaccine production. The clinical signs of a reaction caused by a vaccine are not necessarily specific, however, and such signs may also occur in an unvaccinated population. To try to characterize a vaccine-associated adverse event (VAAE) that might occur after administration of a new vaccine, the nature and frequency of adverse events are initially investigated in pre-licensure vaccine safety trials. These trials however are typically too small in patient number (particularly

in selected breeds) and too short in time to demonstrate uncommon events that might be related to repeated exposures.

Large electronic medical databases now allow for research of uncommon or rare events. A study published in JAVMA (2005) involving more than 1 million vaccinated dogs has provided insights into the incidence and risk factors for vaccine-associated adverse events in dogs. In this study, the electronic medical records of Banfield, The Pet Hospital®, were searched for VAAE diagnosed as non-specific vaccine reaction, allergic reaction, urticaria, or anaphylaxis within three days of vaccine administration in pet dogs. The administered vaccines included *Bordetella*, *Borrelia*, coronavirus, *Giardia*, rabies, parvovirus, and/or a multivalent distemper-adenovirus-parainfluenza-parvovirus-leptospirosis (4 serovars) vaccine. In a 2-year period there were 4678 (0.38%) VAAE diagnosed in 1,225,159 vaccination visits. Small (≤10 kg) dogs were at significantly greater risk of adverse events than larger dogs, and the rate of VAAE per 10,000 dogs at-risk significantly decreased as patient weight increased. Dogs weighing >10.0 to 45.0 kg (>22.0 to 99.0 lb) had approximately half the risk of an adverse event compared to dogs weighing <10 kg (22.0 lb).

Breed risk was noted in the 2005 study, as Dachshund, Pug, Boston Terrier, Miniature Pinscher, and Chihuahua breeds experienced the highest rates of VAAE (in the order noted above, i.e. Dachshunds highest). In an update based on >4.5M dogs, just published in JAVMA (doi:10.2460/javma.23.03.0181), the top 5 breeds with highest AE rates were French Bulldogs, Dachshunds, Boston Terriers, Pugs, and Boxers! In fact, in multivariate analysis, breed was the strongest factor in the determination of VAAE risk – indicating genetics is the major

predisposing factor to vaccine reactions. Adverse event risk was also slightly increased in neutered compared to sexually intact dogs. The VAAE rate significantly increased with each additional vaccine administered at the same office visit (a precipitating cause), but the rate increase was greatest in dogs weighing 5 kg or less (2023 study). Another interesting note from the updated 2023 study is, based on evaluation of individual vaccines, greatest AE risk was associated with rabies vaccine, followed by distemper vaccine, and then leptospirosis vaccine.

In summary, both studies found that besides genetically-related breed-specific allergic sensitivities the greatest risk of allergic reactions was in small dogs (<5kg) given multiple vaccinations at one office visit. This risk is roughly equivalent to increased risk of reaction as you increase the total administered volume (mL) of vaccine per kg of body weight. This indicates a dose-response relationship from antigens common to many or all vaccines. Thus antigens within the vaccines were the precipitating cause of vaccine reactions.

A study from Japan (Ohmori et al 2005), examined the IgE concentrations in sera from 10 dogs that developed allergic reactions within 1 hour after vaccination and sera from 50 dogs that did not develop allergic reactions after vaccination. Of the 10 dogs with reactions, 8 had high levels of specific IgE directed to vaccine, whereas the 50 control dogs had low or no levels of specific IgE to the vaccine. Of the 8 dogs that had high serum IgE levels, seven had specific IgE directed to fetal calf serum (a component of cell culture media), and one dog had specific IgE directed to gelatin and casein (stabilizers in vaccines). All dogs with reactions post-vaccination were either of small breeds and/or were young. These dogs included five Miniature Dachshunds, two Pugs, one Miniature Schnauzer, one toy Poodle, and one Welsh Corgi. The investigators also

measured bovine serum albumin concentrations in different vaccines from 4 manufacturers, revealing average concentrations ranging from 4 to 3669 μg/dose [nearly a 1000-fold variation!]. Thus, excipient proteins remaining from vaccine manufacturing may be the primary cause of immediate hypersensitivity following vaccination. The federal regulating agency for veterinary vaccines, USDA Center for Veterinary Biologics, Ames, Iowa, does not require manufacturers however to measure or report quantities of excipient proteins in vaccines.

Researchers at Purdue University recently conducted proteomic analysis on canine distemper, leptospirosis, Lyme, and rabies vaccines from 4 major manufacturers (manuscript in peer review in 2022); and found that rabies vaccines, whether 1-yr or 3-yr DOI, had 10-20x more proteins identified in the vaccines than were identified in canine distemper, lepto, or Lyme vaccines! This is particularly interesting in light of the updated Banfield study noted above. Thus this information with the recently noted higher VAAE rates strongly suggests that if vaccine reactions occur in a dog (or cat) receiving multiple vaccines then it may be wisest to separate the rabies vaccine out in future administrations!

The AKC Canine Health Foundation funded a study at Purdue to try to expand the study from Japan and evaluate canine vaccines in the US. Post-vaccination serum samples were obtained to measure antigen-specific IgE concentrations in dogs experiencing allergic reactions for comparison with concentrations in vaccinated dogs of the same breed that didn't have reactions. Antigen-specific antibody concentrations were measured in 46 affected and 50 non-affected dogs which had received various vaccines. IgE concentrations were increased in both groups of dogs, and there was no significant difference in the concentration between groups. Fortunately, there

were 33 pairs of littermates (1 symptomatic and 1 asymptomatic) that had received the same vaccine(s) before serum sampling. This study provided further evidence that the major cause of post-vaccinal hypersensitivity reactions is genetic (presumably affecting mast cell degranulation).

A genetic basis for adverse events in people after smallpox vaccination has recently been reported. Indeed, this would be an important point to convey in client communication - genetics can be the primary cause of vaccine reactions. Although genetic factors may exist within breeds, these predisposing factors are not readily discernible or removable. Reducing antigens (as precipitating causes) can still reduce the incidence of adverse events following vaccination. The best way to do this is to reduce the total number of vaccines administered at a single office visit. This reduction was endorsed in the AAHA Canine Vaccination Guidelines published since 2011, but must be tempered with evidence that extending the number of office visits may also reduce compliance!

Immune-mediated cytotoxicities, such as ITP and IMHA, may be a concern to some practitioners as these diseases have been diagnosed in the weeks immediately following a vaccination. There are conflicting results from case-control studies, however, and no strong scientific evidence of cause-and-effect has been found to date. If there is a relationship, it may be that the most important information (antigen history before the vaccination) has not been adequately researched. The recent (2019) ACVIM Consensus Statement on the Diagnosis of Immune-Mediated Hemolytic Anemia in Dogs and Cats summarized their critique of the literature as

there was low or negligible evidence of any associated between vaccination and IMHA in either species.

It is a separate/different question to ask whether you should vaccinate an ITP or IMHA dog, even if the disease is in remission. As immune stimulants, vaccines can certainly contain haptogens and trigger a new cytotoxic event. Failure or postponement of vaccination however also leaves the patient susceptible to potentially fatal infectious diseases, and risk-benefit must be discussed with the client/owner on a case-by-case basis.

Painful swelling of the distal radius/ulna, or other long bones, with radiographic changes consistent with hypertrophic osteodystrophy (HOD) have been noted in young dogs within a week or two of vaccination. Irish Setters, Weimaraners, Great Danes, and German Shepherds seem to have increased risk. Associated findings can include fever, leukocytosis and lymphadenopathy. Glucocorticoids have been demonstrated to be superior to NSAIDs in the treatment of these patients. Anti-inflammatory doses, 0.5-1.0 mg/kg/d prednisolone) may be adequate for some cases, but high-dose pulse therapy (an immunosuppressive dose of 2-4 mg/kg/d tapered within a week to physiologic doses) can produce dramatic improvements in moderate to severe cases.

What about cats? In terms of non-sarcomatous reactions, a dose-response relationship to volume has also been found in cats (documented in the 1990s). This finding from a small clinical study was further documented in a 2007 study involving nearly 500,000 cats. This research investigated immediate (type I) hypersensitivity reactions and localized swelling at vaccine-

injection sites. From this we can infer that a reduction in the number of vaccines administered at one time reduces stimulation of the nonspecific innate immunity, reducing vaccine-associated lethargy, anorexia, and localized swellings. An update to the large 2007 study has recently been initiated.

What about injection-site sarcomas in cats? Due to the infrequent occurrence in a large number of cats and long time to occurrence in any cat, most research has used retrospective studies to investigate these dangerous sequelae to injections. Retrospective studies however cannot determine cause and effect. Although the presence of an aluminum crystal identified an association with vaccination (and use of an aluminum-adjuvanted vaccine), injection site sarcomas have been associated with non-adjuvanted vaccines, adjuvanted vaccines, recombinant vaccines, antibiotic injections, even paradoxically the injection of a NSAID. Research has demonstrated that cats with these sarcomas were more likely to have mutations of their p53 tumor suppressor gene compared to disease-free control cats. Cats with the gene mutation also had faster tumor recurrence and decreased survival compared to cats with sarcomas but without the same gene mutation. This gene mutation has also been recently associated with significantly increased cancer risk (soft tissue sarcomas) in people. Until proven otherwise, a cat with an injection-site sarcoma should be assumed to have this gene mutation, and all future injections kept to an absolute minimum.

It is our clinical impression at Purdue that there are fewer reports of vaccine-associated sarcomas in cats, compared to 10-15 years ago. There may be fewer genetically 'at risk' cats and/or cats today may be receiving fewer vaccines, e.g. FeLV or rabies, than 10-20 years ago. Nevertheless

a small number of cats may presently be at risk. To not vaccinate a cat greatly reduces the possibility of a sarcoma, but it also greatly increases the possibility of infectious diseases. Currently there are no methods to eliminate all risk. Clinicians have investigated alternative anatomic sites for vaccination, including the tail, in order to minimize the potential impact of amputation.

In conclusion, vaccine 'aversion' or giving fewer vaccines can leave our pets unprotected against important, life-threatening infectious diseases. Continuing research in vaccine duration of immunity may influence our ability to ascertain the best revaccination interval for our pets, thus vaccines may potentially be administered less frequently in the future. In pets genetically predisposed, administering fewer vaccines at one time should reduce the likelihood of a vaccine reaction occurring.

References available on request.

COMMUNICATING THE IMPORTANCE OF VACCINATION IN A VACCINE-HESITANT WORLD

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Abstract:

Keywords: risk, protection, communication, infectious disease

The medical journal *Vaccine* published online on August 26, 2023, a study by a researcher at Boston University's School of Public Health who found that canine vaccine hesitancy was prevalent among U.S. dog owners. In a survey more than 50% of dog owners expressed some degree of skepticism about vaccinating their pets, including vaccination against rabies. Some owners (37%) believed that canine vaccination could give their pet autism. (https://www.sciencedirect.com/science/article/abs/pii/S0264410X23010150) This was then reported in *Veterinary Practice News* on Sep. 5, 2023. Are attitudes toward veterinary vaccines changing?

Vaccination protocols for dogs and cats have changed dramatically in the last 50 years. In the 1970s, dogs typically received 2 vaccines, a DHL (distemper-hepatitis-leptospirosis) vaccine and a rabies vaccine. Cats received a FVRCP (viral rhinotracheitis-calici-panleukopenia) vaccine and perhaps a rabies vaccine. By the 1990s, only 20 years later, discovery of new pathogens and/or ways to protect against them provided a large number of choices of possible vaccines to be given to these same patients. Beginning in the 2000s, committees with subject matter experts

began to formulate Canine and Feline Vaccination Guidelines to help "guide" practitioners in the formulation of their practice protocols.

Certain vaccines were considered essential for all dogs or for all cats, and were deemed "core" vaccines. These typically covered selected viral diseases such as canine and feline distemper and rabies. Other vaccines might have merits but were considered non-essential for all in a species, and therefore labeled "non-core".

PROTOCOLS, PROTOCOLS

Practices were developing vaccine protocols even before vaccination guidelines were being published. Published guidelines however became a standard or yardstick by which one could create/assess your own practice's protocols. Protocols were also part of the instructional material in veterinary colleges and demonstrated within their veterinary teaching hospitals. Nevertheless, new graduate veterinarians were probably less influenced by their teaching in school than by what they observed in practices they worked in, past or present.

Without a federal agency per se, e.g. CDC for human vaccines, to define practice protocols nationally, there was not standardization between veterinary practices regarding vaccination protocols. This was particularly true for non-core vaccines, but also true regarding boostering of core vaccines in adults at 1-year versus 3-year intervals. Guidance on non-core vaccine use was presented regarding individual animal risk, typically based on lifestyle, perceived disease exposure risk, and potential for severe disease if naturally infected.

NON-CORE VACCINE USE

Usage of non-core vaccines in dogs and cats is, not surprisingly, quite varied across the United States, but little has been published or otherwise documented about this usage. To attempt to evaluate this nationally, a study was initiated by one of the vaccine manufacturers to determine non-core vaccination rates in a large subset of veterinary clinics across the US for 5 different vaccines (4 canine and 1 feline). The study used the database and assistance of a veterinary data analytics and practice management software company, and there was no identification of specific vaccine brands used (or bias toward/against any specific manufacturers). Specific vaccines investigated included vaccines for canine leptospirosis, *Borrelia burgdorferi* (Lyme disease), *Bordetella bronchiseptica*, canine influenza virus (CIV – H3N2/H3N8), and feline leukemia virus (FeLV). The results of the study were published online in January 2022 (Malter et al. *Vaccine* 2022).

Vaccination rates were determined by first assessing how many dogs/cats in the practice(s) were vaccinated with core vaccines as of Jan. 1, 2020. From this group, rates were then calculated regarding usage of the non-core vaccines (within a 14-month window) in dogs/cats >6 months old in that clinic or practice location. As the data was skewed, medians were calculated for summary statistics rather than averages or means. Median vaccination rates were calculated for each clinic, and for the state if data was available for >10 clinics in that state.

Data was available from 48 states (excluded ID and NV due to small numbers) and 1670 clinics for dogs and 1661 clinics for cats. Data was initially available for approximately 5.5M dogs and

1.9M cats. Of these, approximately 2.8M dogs and 800K cats met core vaccination requirements for calculation of vaccination rates.

Interestingly, at a national level, median vaccination rates at clinics/hospitals for leptospirosis and *Bordetella* were similar at 71% and 69%, respectively. As a median value (the middle, or 50th percentile) that might be considered good or very good coverage, but ranges were quite extensive! For canine leptospirosis vaccines, some clinics had 100% vaccination rates (lepto would be a core vaccine, i.e. for all dogs) but some clinics in the same state had <5% vaccination rates of dogs against leptospirosis. Similarly for *Bordetella*, individual clinic vaccination rates for dogs ranged from >95% to <5% within the same state.

Vaccination rates for *Borrelia* and CIV were much different. Rates for both were very low nationally, but not surprisingly *Borrelia* was very geographically focused (Northeast, upper Midwest, and central Atlantic). Considering only the 11 states listed by CDC as high incidence for Lyme disease in humans, median clinic vaccination rate for dogs against Lyme disease was only 52%. The state with the greatest median vaccination rate for *Borrelia* was New Hampshire at 75%. For CIV, nationally the median vaccination rate was only 5%, and exceeded 10% in only 6 states (MD, IL, MA, OR, MI, OH). Some individual clinics (in 5 states) had median vaccination rates for CIV >90% but these were uncommon.

For FeLV, the median vaccination rate across 48 states was 35%, and in cats 7-24 months of age was 37%. There were 4 states with median clinic vaccination rates >80%, but 16 states with

median clinic vaccination rates <20%. Quite a difference among states, and also quite varied compared to AAHA/AAFP Feline Vaccination Guidelines!

When comparisons were made between clinics which self-reported to be using 1-year versus 3-year protocols for core vaccines, the median vaccination rates for leptospirosis, *Bordetella*, and FeLV were greater in the 1-year protocol clinics than in the 3-year protocol clinics. It is unknown if this difference relates to other differences in protocols or practice management, or if clients on 3-year core vaccine protocols are less compliant in returning annually for other preventive medicine services!

COMMUNICATING ABOUT VACCINES (NON-CORE AND CORE)

While differences in vaccination rates are clearly related to our professional assessment of risk in individual patients, could part of the difference be related to our communication about vaccination?

Even our personal perception of risk can be varied depending on whether it is the risk associated with something good happening versus something bad happening, e.g. winning the lottery versus getting struck by lightning. Whether doctor or client, our decision making is almost always based on evidence in support of a position. The difference is - what (to us) counts as evidence?

For some, evidence could be based on science or research (or does it depend on who did the research?). For some, evidence is based on personal experience or the experiences of those you respect or trust – be they on social media or news media.

When we as doctors communicate about vaccination or the need for vaccination, the communication has 2 very important components: the content AND the process. It has been stated that "data tells, but stories sell!" Sociological investigations suggest that about half of the US population prefers data-based information but the other half prefers personal/relational-based information! We often do not ask the framework for our clients' opinion about vaccination, nor do we share our framework – which could include that we vaccinate our own dog or cat against such diseases.

Subconsciously we are all programmed (for self-preservation) to see what we believe, rather than to believe what we see, i.e. "things are not as they appear". Thus for safety, we focus or are more impacted by statements about negatives than by positives – a negativity bias. For example, making 99 statements about the benefits of something may have less influence than 1 statement about a negative impact of the same thing. Therefore if your statements about vaccines tend to mention negatives or risk of adverse events, then that [the negatives] becomes a subconscious focus for the client. If the client wants to talk about risk of adverse events, do you steer the conversation toward the negative impacts of disease for the pet (and emotional/financial expense to the owner) if not being protected by vaccination?

One source of guidance on canine vaccines for practitioners is the American Animal Hospital Association (AAHA) Canine Vaccination Guidelines, published in 2017 and recently updated in September 2022. The 2017 edition of the Guidelines had an expanded section on risk communication to clients. This emphasizes that communication on infectious diseases as well as

vaccination is not to be neglected (nor assumed). As such, written and signed informed consent is advocated whether vaccination is accepted (consent acknowledging vaccine reaction risk) or refused (consent acknowledging disease infection risk). This communication becomes more important in a post-COVID vaccine-hesitant world.

In summary, we need to be more conscious about our communication (and the communication of our whole practice team) as advocates for the health of our beloved pets – and that includes communication to potentially vaccine-hesitant clients about the value of core vaccines and non-core vaccines in their pets!

References available from author on request.

THE CONTINUING THREAT OF LEPTOSPIROSIS

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Abstract

Keywords: zoonosis, renal, hepatic, infectious

Leptospirosis is a zoonosis found in more than 150 mammalian species, and therefore the risk of this disease to dogs or cats must be dependent on the prevalence of leptospirosis in these species and subsequent environmental exposure risk to dogs. The incidence of canine leptospirosis in the US declined in the 1980s and early 1990s, and interestingly so did human leptospirosis such that CDC removed leptospirosis from its list of nationally notifiable disease (in people) in 1994. Increasing incidence of human leptospirosis however has resulted in CDC making it a notifiable disease again in 2014.

Which serovars are important? The veterinary literature from the 1950s and 60s documented serosurveys of stray unvaccinated dogs in the US, and antibodies against *Leptospira* serovars Canicola and Icterohaemorrhagiae were most common in these dogs. Maintenance hosts for these two serovars are dogs and rats/rodents, respectively. Vaccines were therefore developed in the 1960s to protect dogs against these two serovars. From the mid-1970s to early 1990s, there were few published reports in peer-reviewed literature of canine leptospirosis in the US. This may have been due to reduced infection in reservoir hosts or due to the effectiveness of the bivalent (Canicola and Icterohaemorrhagiae) bacterin. The bacterin was typically marketed as the liquid component of a multivalent canine vaccine. Vaccine-associated adverse events were

sometimes attributed to this bacterin, and post-vaccinal antibody concentrations were reported to decline after 3-6 months, thus leading to questions of the efficacy of this bacterin. Nevertheless, no apparent resurgence of these 2 serovars appeared.

Through the 1990s, case series reports of canine leptospirosis began to document (usually based on serology) infections caused by nonvaccinal serovars. In 1991, Nielsen in Indiana reported 2 lepto cases caused by serovar Bratislava. In 1992, clinicians in Massachusetts reported the canine leptospirosis cases from 1985-1989 in their hospital were predominantly due to serovars Pomona and Grippotyphosa. In 1996, serovar Grippotyphosa was also reported from 11 dogs with acute renal failure in Georgia. The same year, serovars Pomona and Grippotyphosa were reported to cause canine disease in New Jersey and serovars Pomona, Autumnalis, and Grippotyphosa were incriminated in Michigan. Two years later, researchers in New York would report the same 2 serovars as New Jersey, and in 2000 researchers in Davis, CA, would report a predominance of serovars Pomona and Bratislava in their canine leptospirosis cases from 1990-98. They noted that the majority of cases were identified in the last 3 years of their study.

Thus, in the face of possible protection against serovars Canicola and Icterohaemorrhagiae, clinical cases were increasingly attributed to serovars Pomona, Grippotyphosa, Bratislava, and Autumnalis. Serovars Pomona and Grippotyphosa have been recognized pathogens in livestock (cattle and pigs) although until the 1990s they were not pathogens of concern to dogs. They now appear to be established within reservoir wildlife species. The other two serovars (Bratislava and Autumnalis) are documented pathogens on other continents. Bratislava has been associated with clinical disease in pigs (in the US and Europe) and in horses (in Europe), but Autumnalis has not

been isolated from livestock or companion animals in the US. At this time, positive titers to Autumnalis are most likely a cross-reaction from another serovar.

Serovar Icterohaemorrhagiae does remain a threat to many dogs from mice and rats. When sanitary conditions are marginal or house structures allow, rodents in homes can still transmit leptospirosis to dogs who don't go outside! Furthermore as many homes now have backyard poultry (estimated to be >10M homes in the US) the presence of poultry, feed, and litter attract and increase rodent populations and the threat of leptospirosis to dogs.

Clinical signs in dogs are usually attributable to localization of infection to the renal, hepatic, or vascular system. Clinical findings can be quite varied in severity, ranging from acute oliguric renal failure, renal and hepatic disease, fever of unknown origin (FUO), or even no clinical signs (asymptomatic). A general classification of the frequency of organ involvement in canine leptospirosis, based on clinical and diagnostic findings, is: renal only: 30-50%, renal and hepatic: 25-35%, hepatic only: 10-20%, and other (uveitis, myalgia, FUO): 5-10%. Hepatic disease is typically presented as cholangiohepatitis, but several cases of chronic granulomatous hepatitis without renal involvement have also been reported (JVIM 2019). A published report also documented fatal septicemia-like disease in dogs less than 1 year old; these dogs died before a positive-MAT response but were positive for *Leptospira* on special stains of kidney tissue. Some serovars may be more likely to cause disease in certain organs, but there is not consistent evidence to support this perception. Although normally responsive to antibiotic treatment, death can still occur despite treatment (estimated mortality of 15-20% in leptospirosis cases seen at university teaching hospitals).

Determination of the infective serovar and a clinical diagnosis is hindered by lack of a sensitive, specific, low-cost, rapid and widely available diagnostic test for leptospirosis. Most cases of leptospirosis are diagnosed by serology, and the reference method is the microscopic agglutination test (MAT). The MAT is difficult to standardize and requires live organisms for antigens. Cross-agglutination is also common. Despite these drawbacks, the MAT is still the diagnostic norm for many laboratories. Clinicians must presume that the serovar with the greatest antibody titer is the infective serovar, although paradoxical reactions to un-infective serovars have been noted. This is believed to occur most commonly early in infection, due to a non-specific IgM response; the MAT primarily measures IgM rather than IgG. Likewise, clinicians are in a quandary when 2 serovars have equal titers as dual infection is probably unlikely. The use of paired sera (2-4 weeks apart) is often required to confirm the diagnosis and clarify the infective serovar. Problematic however is the capability of leptospiral serovars to alter their outer membrane proteins. This is done in the natural host environment in order to reduce the host immune response to the invader. This transformational ability in laboratory-maintained serovars also could reduce the MAT correlation between laboratories and compared to the infective serovar.

Newer antibody-directed tests have been developed, including ELISA, immunoblot assay, a dipstick method, and a lateral flow assay. Most of these are semi-quantitative tests using a color-change indicator for detecting a titer. These newer tests generally have higher sensitivity in detecting IgM in the first week of infection, but probably no difference by day 14. Advantage to the newer tests compared to MAT may be lower cost, more rapid test results, and improved

sensitivity early in infection; the disadvantages may include no numerical titer, no indication of infective serovar, and an increased risk of false-positive test results due to previous *Leptospira* exposures from environment or recent vaccination.

PCR of urine and/or blood is also used to diagnose leptospirosis before antibiotic administration (early in infection or hospitalization!), but its use and impact have raised new questions. Although PCR is increasingly available through many laboratories, controlled studies have not defined the correlation between PCR and MAT, using a true "gold standard" in a large number of cases. One limitation of PCR-based diagnosis is the inability of most PCR assays to identify the infecting serovar. While this may not be important for individual patient management, serovar identify has important epidemiological and public health value. Not all PCR tests are performed with the same methodology, and sensitivity and specificity may vary. Generally PCR tests are highly sensitive. False negatives are considered uncommon, but can occur with low/zero levels of leptospiruria or leptospiremia. Certain methodologies however may be more prone to reductions in specificity, causing false positive test results. A comparison study of two PCR methods reported there were 0% false-positives in one method but the same samples had 13% false-positives via the other method. PCR positive results however do <u>not</u> necessarily mean there is <u>viable</u> organism, thus you can get positive PCR results from dead leptospires shed when the dog is receiving antibiotics.

Serological evidence in the US clearly supports the use of 4-serovar (Icterohaemorrhagiae, Canicola, Grippotyphosa, and Pomona) vaccines, rather than 2-serovar vaccines; and AAHA Canine Vaccination Guidelines since 2011 do <u>not</u> recommend the use of 2-serovar products.

Leptospiral vaccines are generally considered serovar-specific, and cross-protection between serovars should not be assumed. This concept is being challenged in some research, however, and cross-protection may occur between selected serovars. Recent research suggests that MAT seropositivity for serovars Autumnalis, Grippotyphosa, Bratislava, and Pomona are strongly correlated. Thus, there appears to be some molecular mimicry between these serovars. At Purdue, we have not documented a case of leptospirosis attributable to serovar Bratislava or Autumnalis in a dog properly vaccinated with a 4-serovar product, again suggesting some cross-protection may occur between some serovars.

Which dogs should be vaccinated? Several published studies in the last 10-15 years have found that leptospirosis cases were more likely to be dogs from suburban, or recently urbanized, areas than from rural settings. Wildlife studies at other universities indicate that population densities of peri-urban wildlife may be 8-12 times greater than in their rural counterparts due to increased availability of food and lack of predators, thus increasing disease exposure risk. A review of leptospirosis cases from the VMDB (Veterinary Medical Database) from university teaching hospitals over the last 40 years documents a change in the signalment in diagnosed cases, with dogs less than 15 pounds proportionately more likely to be diagnosed with the disease than dogs in other weight groups. These small dogs in our experience have not been vaccinated against leptospirosis, leaving them susceptible to infection. The pertinent patient history question is not "Does your dog live in the country?" but rather "Does your dog have potential exposure to raccoons, skunks or other wildlife (or specifically their urine) in your neighborhood or backyard?"

Other recent studies in the US and in Canada have documented increasing disease in small breed dogs. In fact, one study showed Labrador retrievers at reduced risk. These findings may merely be a reflection of vaccination protocols, i.e. sporting breed dogs are being vaccinated but small breed (so called 'backyard') dogs are not. Tying this finding with previous studies suggests: 1) urban wildlife such as raccoons and skunks are known carriers of leptospirosis, 2) wildlife populations are often denser in suburban/urban than in rural areas, and 3) small dogs can be exposed to this disease in their backyard due to wildlife activity.

All leptospiral vaccines are similar in that they are bacterins. Recombinant leptospirosis vaccines do not exist. Bacterins can vary in the quantity of whole inactivated bacteria or cell wall antigens present, or in quantity of vaccine excipients (such as bovine serum albumin) remaining from vaccine production. This variation in exogenous protein/antigen most likely explains the occurrence – or lack of occurrence – of allergic reactions following leptospirosis vaccination and observed differences in the rate of these reactions among vaccines by different manufacturers. Nevertheless, current vaccines are much improved in safety compared to the biologicals produced more than a decade ago. New 2022 AAHA Canine Vaccination Guidelines, while leaving leptospirosis as a noncore vaccine, strongly recommends considering it for all dogs and to start the vaccination series at 12 weeks of age or later. Advisory groups appear to be moving toward designating leptospirosis vaccines as core.

Manufacturers typically recommend 2 initial vaccines, and so these can be administered as part of final (rather than all or initial) puppy vaccinations. Annual revaccination is recommended, and supported by epidemiological studies. Because some dogs have low or undetectable

leptospiral antibodies at 12 (or even 6) months post-vaccination, the duration of immunity from leptospiral bacterins has been considered by some to be less than 1 year – even though manufacturers' recommendations are for annual revaccination intervals. Evidence of 12-15 months of disease protection following leptospiral vaccination has been reported in the last decade, and is becoming accepted as the duration of immunity (DOI) for these vaccines. Although infection can occur in a properly vaccinated dog, this is quite uncommon and may reflect a high but less than 100% vaccine efficacy in large populations.

Concern has occasionally been raised regarding data from vaccine trials indicating that vaccinated dogs may develop renal carriage if challenged/exposed to infection. If this is true, there should be documentation of transmission of infection from vaccinated dogs; but such evidence is lacking. Closer examination of experimental data however indicates that the challenge dose of leptospires in vaccine trials probably far exceeds the natural exposure dose. Also, documented renal carriage or leptospire shedding has been noted predominantly with serovar Canicola, the serovar for which the dog is a natural reservoir. Although a chronic-shedding state for dogs remains to be proven by culture, viable organism can be shed in acutely ill dogs - presenting a public health risk to owners, families, and veterinary staff.

Some concern has also been raised about concurrent administration of bacterins with modified live virus (MLV) vaccines. This concern is based on a single research study documenting lower post-vaccinal viral antibody titers after administration of a bacterin compared to no bacterin. The clinical significance of this finding is questionable. All vaccines marketed as multivalent vaccines with leptospiral bacterin as a component with viral vaccines, e.g. distemper or

parvovirus, have been tested in challenge studies to be efficacious for each component of the multivalent vaccine – as required by USDA. Clinical experience, i.e. lack of disease "breaks", also supports the assumption of no decline in efficacy/protection with concurrent vaccinations.

Infections should be treated with a 2-week course of doxycycline, unless they cannot tolerate oral medications. In these cases, initially administer parenteral ampicillin or amoxicillin (IV preferred). Infected dogs are not considered to be of zoonotic risk after 48 hours of antibiotic administration. The soon-to-be-released 2023 Updated ACVIM Consensus Statement on Leptospirosis in Dogs will have more information about the use of dialysis in dogs with severe oliguria/anuria.

What about cats? Does leptospirosis affect cats, and cause clinical disease? Although cats can have exposure to leptospires via rodents or urine-contaminated water (and cats are well known to get kidney disease), published diagnoses of feline leptospirosis have been uncommon in veterinary medical literature until recent years. Cats can, and do, produce titers against leptospirosis; but seropositivity rates in cats are much lower than found in dogs. Some studies have also noted there was no significant difference in seropositivity for cats with kidney disease compared to cats without a history of kidney disease – again suggesting no significant disease impact in this species. Potential explanations include greater innate immune protection against initial infection and subsequent reduced viability of the organism in the feline renal/urinary system.

The testing of cats for leptospires by PCR has recently renewed professional interest in many countries in feline infection. Several studies have noted PCR-positive results in a small percentage of tests of cat urine. The risk of false-positive PCR results should always be considered however by other-than-*Leptospira* organisms or by non-viable *Leptospira*. A critical review of the literature does note that ascites was a physical examination finding on some of the reputed feline cases of leptospirosis. Whether this is a manifestation of a leptospiral-induced vasculitis remains to be determined. Nevertheless, clinical disease in cats appears to be highly uncommon. If diagnostic testing is believed warranted, the use of paired acute and convalescent sera to document a 4-fold rise in MAT titer is recommended. Most titers in cats, if they occur, are very low and would not invoke a positive in-house test result.

An excellent recent literature review on investigations into feline leptospirosis is:
Murillo A, Goris M, Ahmed A, Cuenca R, Pastor J. Leptospirosis in cats: Current literature review to guide diagnosis and management. *J Feline Med Surg*. 2020;22(3):216-228. doi:10.1177/1098612X20903601

Other references available on request

The 2010 ACVIM Consensus Statement on Canine Leptospirosis: *J Vet Intern Med*. 2011;25(1):1-13. doi:10.1111/j.1939-1676.2010.0654.x is in final stages of revision, and the update will probably be published in JVIM online on/about January 2024.

Update on CIRDC – New and Old Causes of Kennel Cough

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Abstract:

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Small animal practitioners are frequently asked to diagnose, treat, and prevent the causes of infectious tracheobronchitis in dogs. "Kennel cough" is a term used to describe a moderately- to highly-infectious respiratory condition spread in boarding kennels, shelters, and 'doggy day care' facilities. A loud, moist or dry, annoying cough often accompanies the contagious condition, potentially affecting the physical health of the dog, the mental well-being of the owner, and the reputation of the facility and veterinarian(s) involved.

"Kennel cough" is typically indicative of a canine infectious respiratory disease complex (CIRD or CIRDC), and may involve one or more pathogens. Pathogens may be either primary etiological or secondary opportunistic agents, and these roles may change somewhat during the course of the disease and as influenced by antimicrobial therapy. Thus, agents can act sequentially or synergistically to cause clinical disease. Although vaccines are available to protect against some of the pathogens, outbreaks occur despite vaccine use. Vaccine-induced immunoprotection tends to focus toward either IgG or IgA antibody production but generally not both.

Some pathogens have been recently identified as new etiological agents of concern to the canine respiratory tract, or have become of increased importance compared to our previous understanding of their role in respiratory disease. A review of CIRDC pathogens will be helpful.

Bordetella bronchiseptica - *B. bronchiseptica* is a gram-negative, aerobic coccobacillus that is regarded as one of the principal causative agents of CIRD. It is related to *Bordetella pertussis*, the cause of whooping cough in people. It (*Bb*) may also be a critical complicating factor in dogs concurrently infected with a viral pathogen. As noted with other non-viral pathogens, *B. bronchiseptica* can be isolated from clinically healthy dogs and cats, as well as from those with respiratory disease. The complexity of the bacteria-host interaction is attributed to a virulence-control system which regulates the proteins responsible for the expression of virulence factors. Furthermore, bacterial attachment can induce ciliostatis which not only prevents bacterial clearance but also enhances further colonization.

Bordetella isolates from lower respiratory tract disease have been reported to be susceptible to several antimicrobials, i.e. amoxicillin-clavulanic acid, chloramphenicol, aminoglycosides, and tetracyclines. *Bordetella* isolates were generally not very susceptible to cephalosporins or fluoroquinolones.

Vaccines to protect against *B. bronchiseptica* are increasingly used in the US as dog-to-dog interactions increase through boarding or day care facilities. *Bordetella* vaccines may be killed products administered parenterally in 2 doses, or may be attenuated live products administered intranasally or orally as 1-2 doses. The parenterally administered vaccines is generally considered a better stimulant of IgG immunity, and the intranasally administered vaccines better stimulants of IgA immunity in the upper airway (a better deterrent to clinical

signs?). In a 2015 review article in The Veterinary Journal, Dr. John Ellis stated it is likely that some combination of mucosal and parenteral vaccination will provide the broadest and longest lasting immunity. This so-called 'heterologous prime/boost' approach to immunization, using different forms of an antigen administered by different routes, is a major focus of research in human medicine, including whooping cough. There is a small study in dogs that supports this concept or strategy, although the optimal booster protocol is not known.

An experimental study in dogs (2017) compared intranasal vs. oral *Bordetella* vaccine. Most (10/16) orally-vaccinated dogs had coughing scores in the same range as the intranasally-vaccinated dogs, but 6/16 had more coughing that IN dogs. Why the difference? Possible explanations for the observed difference include (1) difference/superiority in the biological itself, (2) impact of route of administration [do some dogs receive/swallow the oral vaccine?], and/or (3) difference in immunity stimulation by route site.

Note of caution: Although live vaccines have a more rapid onset of immunity, and typically have a better safety record than parenteral, live vaccines may bear the risk of *Bordetella* transmission to immunocompromised owners or family members!

Mycoplasmas - Mycoplasmas are microorganisms that are enclosed in a cytoplasmic membrane but lack a rigid, protective cell wall. They are part of the natural mucosal flora of dogs and cats, and thus they can be isolated from both diseased and healthy animals. When found in clinically ill animals, other pathogens particularly viruses can also be isolated. *Mycoplasma cynos* and *Mycoplasma canis* are capable of causing loss of cilia on bronchial and bronchiolar epithelial cells and generalized bronchopneumonia. They can be found on both ciliated and non-ciliated epithelium. The primary role of mycoplasmas may be in exacerbating bronchopneumonia

secondary to other pathogens. Mycoplasmas may also be selectively favored in diseased patients receiving ampicillin or cephalosporins. The role of mycoplasma infections of dogs with respiratory disease may have been underestimated in the past due to lack of PCR tests. A 2019 study in PLoS One incriminated *M. cynos* as an important pathogen in clinically ill dogs, and a systematic review (JVIM 2019) found a significant association between *Mycoplasma* spp. and lower respiratory tract disease in dogs.

The mycoplasma's lack of a cell wall confers resistance to cell wall-inhibiting antibiotics such as beta-lactam penicillins, cephalosporin, and vancomycin. Mycoplasmas are also typically resistant to potentiated sulfonamides *in vivo*. Mycoplasmas are generally susceptible to macrolides (erythromycin, azithromycin, tylosin), tetracyclines, chloramphenicol, lincomycin, clindamycin, and fluoroquinolones.

Pasteurella - *Pasteurella* spp. are gram-negative, facultative anaerobes which are often isolated from dogs with pneumonia. The bacteria are considered indigenous microflora of the nasopharynx and large airways. Concurrent infections or stresses may lead to proliferation of *Pasteurella* with the organism gaining access to the lower airways. Gram-negative bacterial endotoxin decreases pulmonary surfactant and affects pulmonary gas exchange. Bacterial proliferation can result in an influx of inflammatory cells and cytokine mediators, and a fibrinopurulent exudate typical of *Pasteurella* pneumonia.

Pasteurella isolates from lower respiratory tract disease have been reported to be susceptible to many antimicrobials, i.e. amoxicillin-clavulanic acid, cephalosporins, chloramphenicol, fluoroquinolones, aminoglycosides, and tetracyclines. *Pasteurella* isolates were not highly susceptible to ampicillin or potentiated sulfonamides.

Streptococcus zooepidemicus - *S. zooepidemicus* is a beta-hemolytic, group C bacterium that is distinct from group G bacteria, such as *Streptococcus canis*, which are more commonly isolated as commensal organisms from dogs. The rapid clinical course that characterizes most cases of *S. zooepidemicus* resembles streptococcal toxic-shock syndrome in humans. Canine isolates of *S. zooepidemicus* have been shown to contain known exotoxin genes similar to those occurring in streptococci in other species. As a single pathogen, clinical disease is not consistently produced in experimental challenges. With other pathogens, notably CIV H3N8, a synergism in pathogenicity is noted compared to single pathogens alone.

Initial signs can include a moist cough and serous or mucoid nasal discharge. Fever, rapid progression to depression, anorexia, and dyspnea are common with death within 24-48 hours of initial signs. Lesions are remarkably consistent in almost all dogs, with severe acute fibrinosuppurative, necrotizing, and hemorrhagic bronchopneumonia with pleuritis. Exotoxins are believed to act as superantigens which damage the pulmonary vasculature leading to fibrin leakage, edema, and widespread hemorrhage.

Although streptococci are generally susceptible to ampicillin and amoxicillin, clindamycin may be preferred in treating toxic-shock-like conditions. Clindamycin has anti-bacterial properties, is also a potent inhibitor of bacterial toxin synthesis, and suppresses monocyte synthesis of TNF.

Canine Parainfluenza Virus (CPIV) - CPIV is a paramyxovirus that is an increasingly common cause of highly contagious (but generally self-limiting) cough in dogs. Laryngitis and tracheitis may be associated with episodic gagging and expectoration. A serous nasal discharge,

tonsillitis, with or without pharyngitis, may develop. CPIV replicates primarily in the upper respiratory and can be isolated from the nasal mucosa, pharynx, larynx, trachea and bronchi. In the absence of a complicating secondary infection, clinical signs due to CPIV resolve in 6-14 days. The 2019 study in PLoS ONE incriminated co-infections, particularly of CPIV with Mycoplasma, as associated with the highest clinical scores in sick dogs.

CPIV vaccines are available with a MLV component of a multivalent parenteral vaccine most commonly used as part of distemper and CAV-2 vaccinations. CPIV can also be delivered with intranasally, and products are available which combine this component with an avirulent live *B. bronchiseptica* vaccine. As noted with *Bordetella* vaccines, parenteral and intranasal vaccines have two different routes of administration and evoke two different primary immunoprotective mechanisms. There are no published comparisons in populations detailing the clinical efficacy in natural settings of either type vaccine, or of the efficacy of concurrent or alternating use of these products.

Canine Respiratory Corona Virus (CRCoV) - CRCoV belongs to the *Betacoronavirus* genus of the *Coronavirus* family. CRCoV is serologically and genetically distinct from canine corona virus (CCoV), an *Alphacoronavirus* which is typically an etiological agent of enteric disease. CRCoV is associated with mild respiratory disease in the early stages of CIRD. Typical clinical signs include a dry cough and nasal discharge, which are not unique to this viral agent. CRCoV most commonly creates high viral loads in the trachea and nasal tonsil, but virus can be detected and isolated from a wide range of respiratory tissues and respiratory-associated lymphoid tissues.

Exposure to CRCoV causes inflammation in the nares and trachea with injury or loss of tracheal cilia. Histological changes may be detected as early as 3 days post-infection and may

remain evident 14 days post-infection. The damage to the mucociliary clearance mechanisms of the upper airways may predispose dogs to secondary infections. As CRCoV is found most frequently in the trachea and nasal cavity, oropharyngeal and/or nasal swabs are considered the most suitable diagnostic samples.

Canine Influenza Virus (CIV) - This virus was first detected in racing Greyhounds in Florida in 2004, and genetically the virus was most closely related to equine influenza virus H3N8. As is common to influenza viruses, the virulence seemingly decreased after the disease was first detected nearly a decade ago; but the initial cases with high mortality may have been co-infected with *Strep. zooepidemicus*. H3N8 CIV infection can cause clinical signs in the absence of vaccination and lack of previous exposure. Initially, clinical signs involved necrotizing lesions in the respiratory tract and relatively sudden death. Less dramatic signs may be more common now, including mild anorexia, lethargy, coughing, and nasal and ocular discharge. Thus CIV infection can affect either the upper or lower respiratory tract, or both. CIV infection may result in a greater incidence of lower respiratory tract involvement than other canine viruses. Within the pet dog population, fatal cases of uncomplicated CIV-pneumonia are rare.

In March 2015, a large outbreak of "kennel cough" occurred in Chicago with some clinics reportedly presented with 10-15 new cases a day. Dogs were febrile (temps as high as 106^{o} F) and anorectic, but mortality was low. Frustratingly, diagnostic tests including PCR panels were generally negative. On April 12, 2015, Cornell University announced that the infection was canine influenza virus H3N2, a strain recognized in Korea (and some other parts of Asia) but not in the US previously.

Clinical signs are often marked but only lasting 5-7 days, treated with supportive care. Importantly for disease transmission, virus shedding is greatest 1-2 days before clinical signs and the first few days of clinical illness. Virus then rapidly drops off, but virus shedding has now been documented in some dogs for up to 21 days. The virus is susceptible to most disinfectants, but can be spread for 1-2 days by fomites. Segregation and isolation of patients helps to rapidly reduce spread of the disease.

Laboratories (commercial, university, and state) now test for H3N2 as well as H3N8 CIV, and antibody testing also indicates that immunity to the virus is somewhat widely dispersed but at moderate to low levels in dogs across the U.S., not necessarily a result of vaccination. Vaccine manufacturers produce bivalent (H3N2 and H3N8) CIV vaccines. Bivalent CIV vaccines are recommended for dogs commonly exposed in group housing settings to include boarding and dog daycare facilities.

Canine Herpes Virus (CHV-1 or CaHV-1) - The host range for this virus is restricted to dogs only, and has not received much attention for many years. It was recognized to cause severe, often fatal, disease in puppies 1-6 weeks old, but infections in adults were considered to typically be mild, self-limiting upper respiratory tract infections. A small (n=4) dog case series and reports on the ACVIM SAIM listserve have noted rapidly fatal respiratory infections in adult dogs. These have generally been isolated events, e.g. in GA, MS, OK, although several of the dogs had recently been in boarding facilities. Fatal cases died within 2-5 days of developing clinical signs. Diagnoses have come from virus isolation and PCR (lung and nasal swabs). Necropsies revealed diffuse hemorrhagic bronchopneumonia; no other pathogens were isolated in several of these cases. A number of these cases had dendritic (branching) corneal ulcers, with

the owners first noting “red” eyes and seeking an ophthalmology as well as respiratory consult. As there is no definitive treatment, antiviral therapy has been advocated by some internists but the benefit/efficacy of such treatment in these cases is unknown.

Canine Adenovirus type 2 (CAV-2) - Although this pathogen can cause acute infectious laryngotracheitis in susceptible dogs, clinical disease is generally mild. Most dogs however acquire immunoprotection via their puppy vaccination series in which CAV-2 is part of a multivalent distemper (CDV) vaccine. CAV-2 is likely an important pathogen however in unvaccinated dogs.

Approach to Diagnosis

One should attempt to identify an etiological agent (or agents) if dogs (1) have severe or rapidly progressive clinical signs, (2) have clinical signs for more than 7-10 days, or (3) are in an outbreak or group setting. Although samples for culture and PCR tests can be obtained from nasal swabs, oropharyngeal swabs, tracheal washes, bronchial washes, or bronchoalveolar lavages, lower respiratory tract sampling is preferred. Nasal and oropharyngeal samples can yield normal flora.

Approach to Treatment

Most dogs with uncomplicated signs of CIRDC only require supportive care (or no treatment) and spontaneously resolve within a week. There are currently no labeled antiviral therapies for dogs with CIRDC, and no published recommendations of use of human products in dogs. Dogs with clinical signs beyond 1 week and/or systemic signs, e.g. pneumonia, should be treated with

antimicrobials. Published guidelines for outpatients recommend use of doxycycline (5 mg/kg PO q12hr) or amoxicillin-clavulanate (12-20 mg/kg PO q12hr). For inpatients with more complicated disease, administer IV fluids (and O_2 if needed) and doxycycline (5 mg/kg IV q12hr) or either clindamycin (5-10 mg/kg IV q8hr) or ampicillin (10-20 mg/kg IV q8hr) with enrofloxacin (10 mg/kg IV q24hr).

Approach to Prevention

Vaccines are available for several common CIRD pathogens, but not for all. Also, most vaccines do not produce sterilizing immunity but rather decrease the severity of clinical signs and magnitude of pathogen shedding. Mucosally administered live vaccines generally produce a most rapid onset of immunity than killed products. Intranasal administration is generally preferred over oral, although some (but not all) studies have shown them to yield equivalent protection.

Helpful references (free online):

Reagan KL, Sykes JE. Canine Infectious Respiratory Disease. Vet Clin North Am Small Anim Pract. 2020 Mar;50(2):405-418. doi: 10.1016/j.cvsm.2019.10.009. PMID: 31813556; PMCID: PMC7132485.

Lappin MR, et al. Antimicrobial Use Guidelines for Treatment of Respiratory Tract Disease in Dogs and Cats. J Vet Intern Med. 2017 Mar;31(2):279-294. doi: 10.1111/jvim.14627. PMID: 28185306; PMCID: PMC5354050.

Other references available on request.

Preparation for Successful Dental Extraction

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1

Regional Dental Blocks

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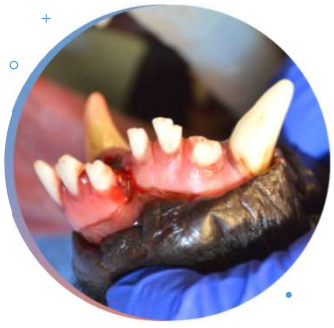

Indications:

- Any potentially painful oral procedure.
- Dental extractions
- Oral biopsies or mass removals
- Guided tissue regeneration
- Root canal procedure
- Trauma repair

3

Anesthetic Agent

Lidocaine
- Toxic dose of 5 mg/kg – usually do not surpass 4 mg/kg
- Onset of action: 2-5 minutes
- Duration of analgesia: 1-2 hours
  - Surgical stimulation – 45 min – 1 hour

Bupivacaine
- Toxic dose of 2 mg/kg – usually do not surpass 1 mg/kg
- Onset of action: 10-15 minutes
- Duration of analgesia: 4-6 hours

*Note: Toxic/fatal if administered intravenous!

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Volume per site for Dental block

Variable based on patient size:

- Cat or small dog (<10kg) – Calculate toxic volume and divide by 4
- Medium dog (10-25kg) – 0.2ml-0.4ml per site
- Large/giant breed dogs – 0.5ml-1ml per site

Note: These are suggestions only and clinical judgment should be used when determining anesthetic volume.

The more volume used – the further the anesthetic agent will diffuse.

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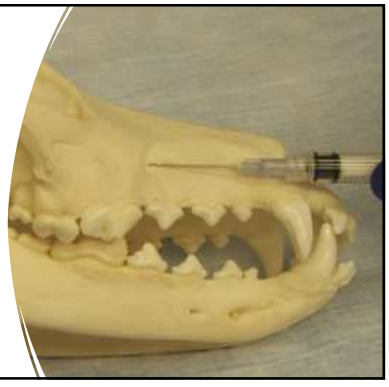
Infraorbital Block

Blocks buccal bone and soft tissue near PM3/4 and rostral.



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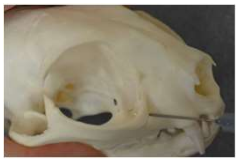
Infraorbital Block

Exception for very small toy dogs, cats and brachycephalic breeds:
This may block the molars as well.



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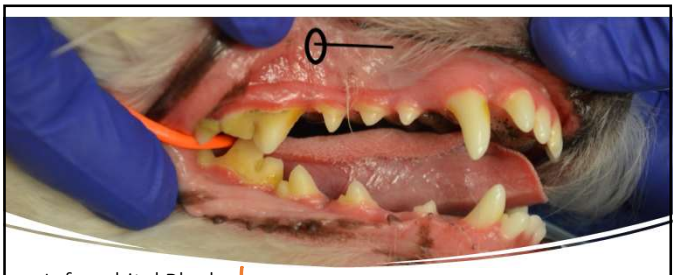

Infraorbital Block
Canine

1. Palpate infraorbital foramen/bony ridge.
2. With the lip retracted dorsally advance the needle along the maxilla under the bony ridge, parallel to the dental arcade.
3. Aspirate then administer.

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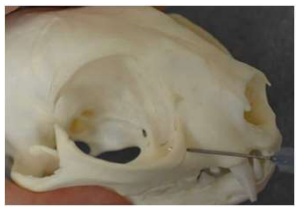
Infraorbital Block
Feline



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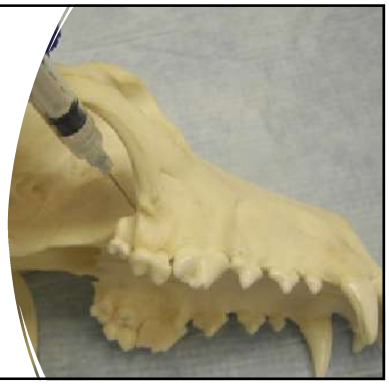
9

Maxillary Block

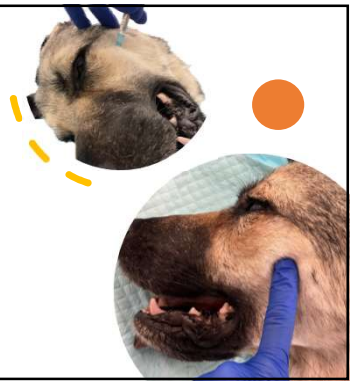
Blocks buccal bone and soft tissue of entire maxillary arcade.



10

Maxillary Block

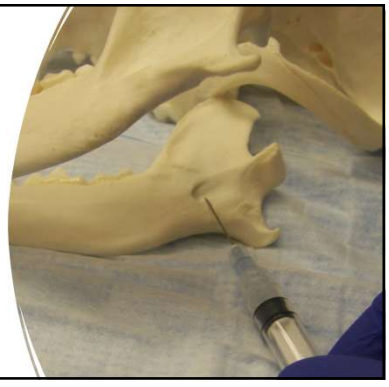
1. Palpate the last maxillary molar and the zygomatic arch.
   - Make sure that the mouth is in a relaxed/closed position.
2. Insert the needle through the haired skin perpendicular to the maxilla.
3. Aspirate then administer.



11

Mandibular Block (Inferior Alveolar)

Blocks buccal bone and soft tissue of entire mandibular arcade.

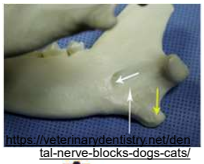


12

Mandibular Block

Palpate the angular process of the mandible through the haired skin (yellow arrow).

Note the inferior alveolar nerve (short white arrow)and the location of the intended needle placement (long white arrow).



https://veterinarydentistry.net/dental-nerve-blocks-dogs-cats/

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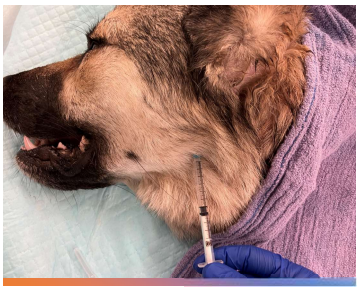

Mandibular Block

1. Advance the needle on the lingual surface of the mandible just rostral to the angular process of the mandible.
   - Hold syringe and needle perpendicular to the mandible.
   - Can "hit" mandibular bone then "walk" off toward the lingual surface.
   - Advance the needle approximately ½ width of mandible.
2. Aspirate then administer.

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Potential Complications of Regional Dental Blocks

Benefits:

- **Patient comfort improved.**
  - During procedure and in recovery.
- Increased stability of anesthetic plane – inhaled gas sparing.

Potential Complications:

- Administration of anesthetic agent intravenous.
- Numbing of areas adjacent to preferred region:
  - Maxillary – retrobulbar space.
  - Mandibular – lingual nerve.
- Hematoma formation.

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Mucogingival Flaps

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Mucogingival Flaps

These flaps allow for access to underlying structures and facilitate tension free closure of surgical sites.

Plan ahead:
- What type of flap to make?
- If and where you are going to make any vertical incisions?
- Pay attention to the anatomy.
- How much tissue you have to work with?

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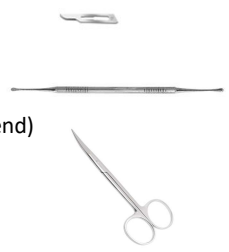
Mucogingival Flaps

Equipment needed:

- #15 scalpel blade
- Periosteotome (double end)
- Gingival/iris scissor
- Preferred suture
  (4-0 or 5-0 Monocryl, taper)



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Envelope Flap

A sulcular incision is made into the attached gingiva parallel to the tooth.

Gingival elevator is used to expose the buccal bone.

No vertical incisions are made.

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Mucogingival Flap

Sulcular incision

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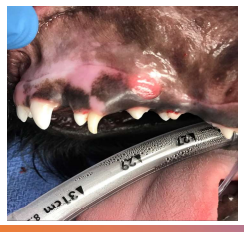

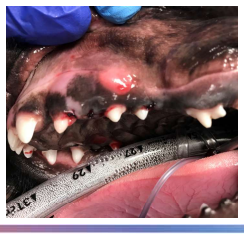

Clinical Applications

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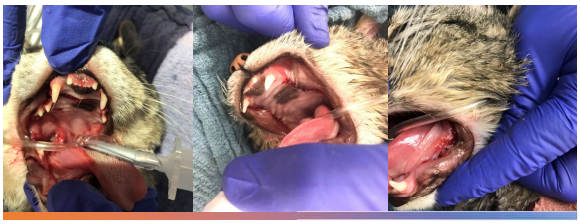

Clinical Application

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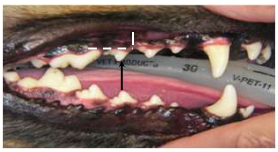
One Vertical Incision Flap



A sulcular incision is made into the attached gingiva parallel to the tooth

One vertical full thickness incision is made traversing apically past the mucogingival junction

Gingival elevator is used to expose the buccal bone

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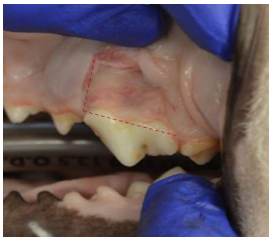
Mucogingival Flap



Single vertical incision flap

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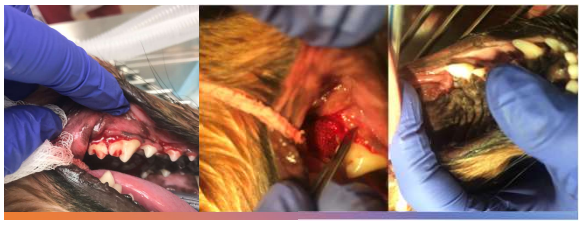

Clinical Application

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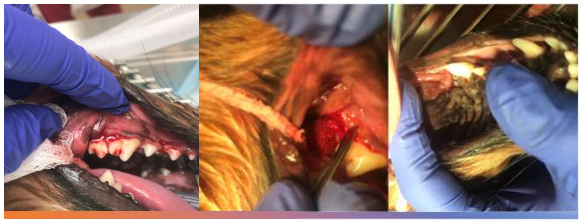

Clinical Application

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Two Vertical Incision Flap

A sulcular incision is made into the attached gingiva parallel to the tooth

Two vertical full thickness incisions are made traversing apically past the mucogingival junction

Gingival elevator is used to expose the buccal bone

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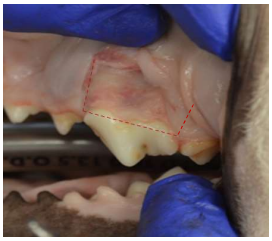
Mucogingival Flap



Double vertical incision flap

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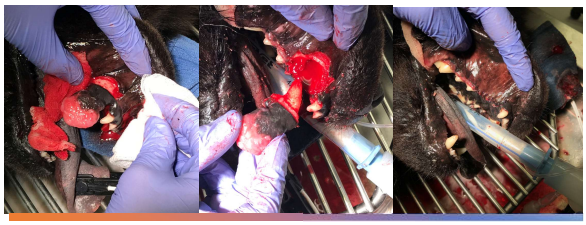

Clinical Application

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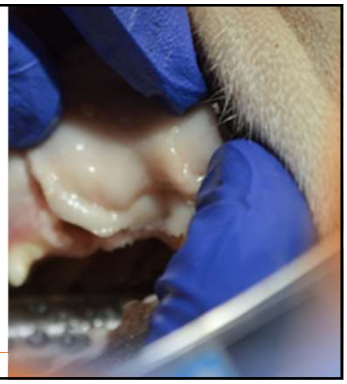
Flap Closure

- **Tension free** closure is a must!
- Shape the flap for best fit, fresh tissue edges.
- Gentle tissue handling is important.
- Release the periosteum to allow for more mobility of the flap.



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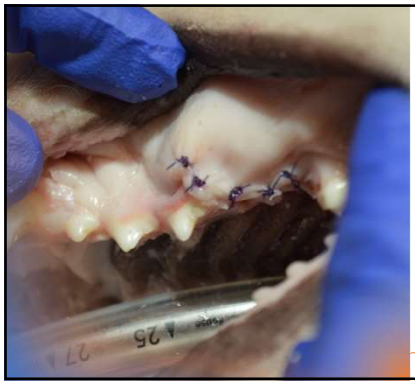

Flap Closure

Simple interrupted suture pattern with sutures 1-2 mm apart.

Corners are secured first

4 - 6 throws for each knot

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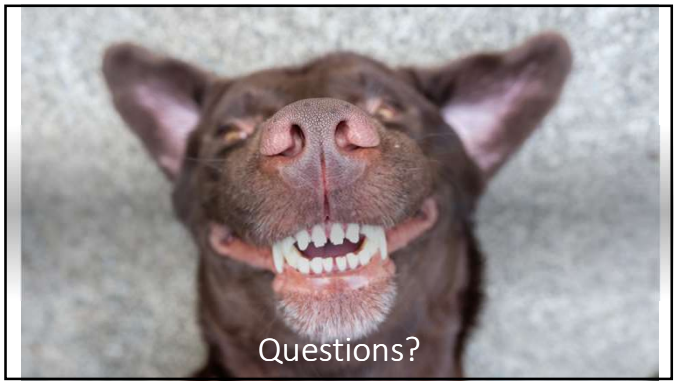

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Clinical Management of Feline Chronic Gingivostomatitis

Erin Chamorro, DVM
Assistant Clinical Professor
Auburn University College of Veterinary Medicine
Small Animal Dentistry and General Medicine

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Literature Review

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What is it?

- A chronic oral mucosal disease caused by an atypical patient immune response.
- Prevalence: 26% of feline population.
- Characterized by inflammation that crosses the mucogingival junction, can be erosive or proliferative in nature.

AKA: Lymphocytic Plasmocytic Stomatitis, Caudal Mucositis

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Disease Characteristics

- Likely associate with chronic viral infection: Calicivirus infection
- Retroviral infection leads to poor response to therapy.
- More common in multi-cat households. Each additional cat in household increases risk by 70%.
- Increased oral microbiome diversity in cats with FCGS.
- Local disease most notable but has systemic sequelae as well.

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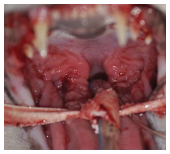
Disease Management

Goals:

1. Decrease or eliminate oral antigenic stimulation.
   - Targeted dental extractions.
2. Modulate abnormal immune response.
   - Immunomodulatory therapy



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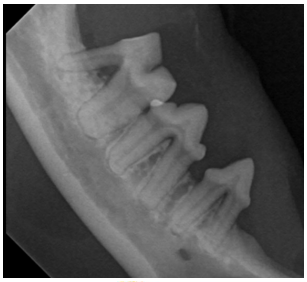
Caudal or Full Mouth Dental Extractions

- 93% of patients with FCGS had moderate to severe periodontitis.
- 66% of patients with FCGS had tooth resorption.

Removal of teeth decreases chronic inflammation and decreases oral bacterial load.



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Caudal mouth extractions

Therapeutic Management of Feline Chronic Gingivostomatitis: A Systematic Review of the Literature

- Response to Caudal Mouth Extractions (Published July 2016)
  - 28.4% Complete remission
  - 39.0% Significant improvement
  - 26.3% Little to no improvement
- No significant difference between full mouth extractions or caudal mouth extractions.

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Medical Management

Should not be used as the only therapy but in combination with surgical intervention.

- Analgesia
  - Buprenorphine recommended
    Note: Transmucosal absorption may be decreased in these patients.
  - Alternate medications include gabapentin, amantadine, nsaids, other opioids.
- Antimicrobials
  - Perioperative, short duration (5 days)
  - Clavamox (13.75mg/kg PO q12h) or clindamycin (5-11 mg/kg PO q12h)
- Immunosuppression
  - Not recommended.

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Refractory CFGS

Defined as patients with no improvement 2 months after therapeutic extractions.

- Immunosuppression
  - Glucocorticoids – Clinical improvement in 23% of patients.
  - Cyclosporine – Clinical remission in 50% of patients.
- Immunomodulation
  - Recombinant feline interferon-omega (rFeiFN-ω) – Clinical improvement in 45% of patients (indicated for those with confirmed viral infection).
  - Mesenchymal stromal cell (MSC) therapy
    - Allogenic – Clinical improvement in 57% of patients.
    - Autologous – Clinical improvement in 71% of patients.

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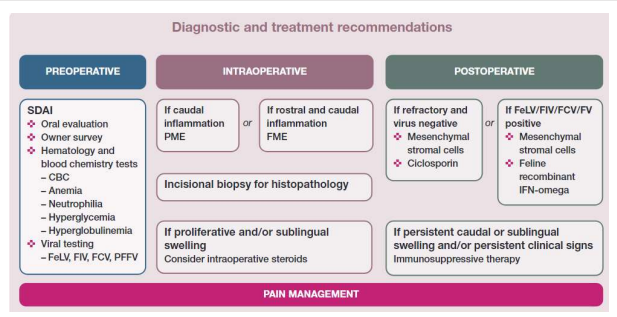

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Clinical Management

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Clinical Presentation

- Owner reported symptoms include halitosis, changes in eating behavior, decreased grooming, changes in social behavior.
- On examination, severe oral pain, ulcerative or inflammatory changes to mucosa extending away from gingiva

Pain management strongly recommended prior to oral examination.

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Initial Diagnostic Testing

Complete Blood Count	• Occasionally patients will have elevated white blood cell counts.
Blood Chemistry	• Commonly patients will have elevated globulins.
Thoracic radiographs / Echocardiogram	• Performed when > 8 years or cardiac murmur detected.
FeLV and FIV testing recommended +/- calicivirus testing	• Results may offer prognostic information.

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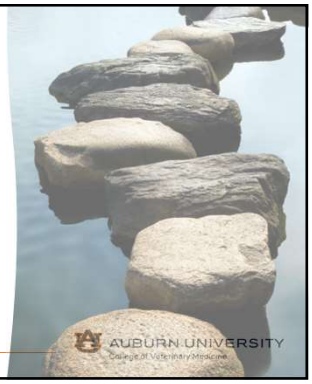
Treatment Planning

- Clear client communication is essential.
- Complete Oral Health Assessment and Therapy recommended
  - Prior to procedure obtain clear understanding of client goals.
  - Assure client understands prognosis and likelihood of multiple procedures.



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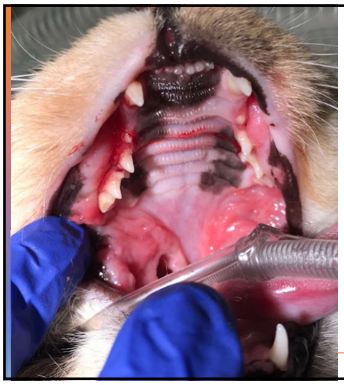

Dental Procedure

- Complete dental and oral exam with probing.
- Whole mouth dental radiographs.
  - Include areas where teeth are missing.
- Biopsy of affected tissues for definitive diagnosis.

Extraction of diseased teeth vs. caudal mouth extractions vs. full mouth extractions

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Targeted Dental Extractions

- Extraction of diseased teeth only:
  - Patients less than 2 years of age
  - Minimal or absent caudal mucositis
  - Clinically comfortable.
- Caudal Mouth extractions:
  - Caudal mucositis
  - Clinical disease
  - Owner preference
- Full mouth extractions:
  - Caudal and rostral mucositis
  - Disease of canine teeth is present

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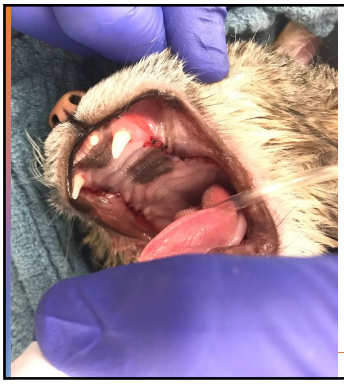

Surgical Procedure

- One arcade at a time – open to close.
- Sulcular incision mucogingival flap across entire arcade.
- Simple interrupted suture pattern
  - 5-0 Monocryl, taper needle

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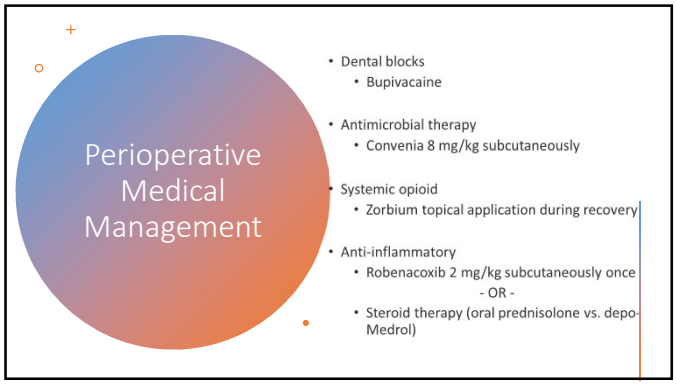

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Procedure Aftercare

- Soft food only for 2 weeks
  - Ideal but food intake most critical, easier to prehend
  - Convalescent diet – high palatability, higher protein
  - Appetite stimulant if needed
- E-collar
- Keep confined and away from other cats for 48+ hours.
- Medications dispensed:
  - Gabapentin (5-10 mg/kg) to add to food in case of refractory pain or anxiety.

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Follow Up

- Phone call with owner 1-2 days post-operatively
- Surgical site evaluation at 2 weeks
  - Monitoring for dehiscence.
- Oral examination every 1-2 months until resolution of inflammation or determine patient is refractory.
  - Symptomatic management as needed during this time.

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Refractory Patient Management

- Immunosuppression
  - Glucocorticoids
  - Cyclosporine
- Immunomodulation
  - Recombinant feline interferon-omega (rFeiFN-ω)

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QUESTIONS?

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Common Dental Problems

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Fractured Teeth

Fractured teeth are one of the more common dental problems seen in small animal practice. The most commonly affected teeth are the canines and upper 4th premolars, however, any tooth can be affected. The likely cause of premolar or molar fractures is chewing habits, i.e., bones, antlers, hard nylon chews, rocks, sticks and hard nuts. When canine teeth are fractured it is often the result of blunt trauma to the mouth. While pain is certainly present, it is often not observed by the owner. Only after treatment do clients mention the return of a behavior that may suggest pain was previously present.

Teeth can be fractured with or without pulp exposure. All teeth with cracked or portions of the crown missing should be evaluated. Teeth with pink or brown spots on a fractured surface should be considered to have pulp exposure until proven otherwise. All fractured teeth should be radiographed to help determine viability. Treatment options for fractured teeth with pulp exposure are either root canal therapy or extraction. Wait and see should not be an option, as this requires the pet to endure unnecessary pain. While extraction is 99%+ successful, it is more painful and there is loss of function of the tooth. Root canal therapy preserves function of the tooth and is typically 95%+ successful.

Discolored Teeth

Discolored teeth are usually the result of some type of blunt force trauma to the tooth causing a contusion (think bruise) to the pulp. Because the tooth is a closed vessel, the swelling that results from the trauma causes an increase in pressure inside the tooth. This pressure increase can result in death to the pulp and forces the internal hemorrhage within the tooth out into the dentin of the tooth. Initially, this causes a pink color in

the tooth later changing to a purple and then to a gray color.

The vitality of discolored teeth can be evaluated by transillumination with a bright light such as the light of an otoscope without the cone however it is not 100% reliable. A non-vital tooth will have a shadow within the tooth when compared to the opposite tooth. Dental radiographs of the discolored tooth and the opposite tooth can be compared, looking at the root canal size. If the discoloration has been present for an extended time there will be a difference in root canal diameters. Many times, especially when only a portion of the crown is discolored, the tooth will need to be re-radiographed one year later.

A study by Frazier Hale of Canada noted that 93% of these discolored teeth were non-vital. He further noted that only about 40% showed any radiographic changes. He concluded that discolored teeth can be assumed to be non-vital and should be treated either by extraction or root canal therapy.

Clinically, almost all teeth I have seen with intrinsic staining involving more than 50% of the crown have been non-vital when treated.

Chronic Ulcerative Paradental Stomatitis (C.U.P.S.)

CUPS is a condition of dogs that typically involves severe, generalized inflammation of the gingiva and buccal mucosal. It appears this is the result of a hyperimmune reaction to plaque. While this can affect any dog, it appears there may be a predisposition in Cocker Spaniels, Maltese, Cavalier King Charles Spaniels and Schnauzers.

Clinical signs include severe gingivitis with pain, halitosis, oral ulcers (kissing lesions), soft yellowish plaque, hyper-salivation and ulcers on the margins of the tongue. Diagnosis is based on clinical signs and biopsy results.

Treatment is based on plaque control; however, this is often very difficult due to the oral pain present. Initially, a complete dental cleaning and evaluation should be performed. Any periodontally compromised teeth should be considered for extraction as these teeth and their gingival recession creates a plaque retentive surface. Homecare is a must if there is any hope of saving teeth, however, the pain associated with CUPS often makes it difficult. Oral chlorhexadine rinses, chlorine dioxide and/or brushing are helpful, if possible. Eventually, multiple extractions leading to

caudal or full mouth extractions are necessary.

CUPS can be a very frustrating condition to deal with and holds a guarded prognosis for complete resolution. If there is a response to the dental cleanings, they will need to be done every 3-6 months. Many times the tongue margin ulcerations persist.

Lymphocytic Plasmocytic Stomatitis (LPS)

LPS is a condition of cats that typically involves severe, generalized inflammation of the gingiva and buccal mucosal. It appears this is the result of a hyperimmune reaction to plaque. It can affect any cat but the Abyssinian and Somali breeds appear predisposed.

Clinical signs include severe gingivitis and pain with hyersalivation. Often these cats show weight loss due to a reluctance to eat as well as bloody saliva. Diagnosis is based on clinical signs and biopsy results.

Many treatment regimes have been reported, including corticosteriods however it appears extractions are usually necessary as medical based treatments have limited response times. Often selected extraction of periodontally diseased teeth help reduce the inflammation, however, it seems most cases eventually need at least caudal mouth extractions. It is important to completely extract the entire tooth (or roots of missing teeth) and debride the periodontal ligament from the alveolus. In an article by Dr. Phillipe Hennet in a 1997 Journal of Veterinary Dentistry he reported that caudal or full mouth extractions improved the inflammation in 80% of the cats.

Oral Growths

There are a number of types of oral growths commonly seen in the oral cavity of dogs and cats. These growths could include gingival hyperplasia, epulides, melanoma, squamous cell carcinoma, fibrosarcoma or osteosarcoma. Dental radiographs are important to evaluate for bone involvement however the most important diagnostic tool for any oral growth is biopsy, no matter how minor, to determine if additional therapy is required.

Epulides are one of the more common tumors found in the mouth of dogs. Typically, they are benign tumors that originate from the periodontal ligament. Perpherial odontogenic fibroma’s , formerly called fibromatous

epulis are considered benign, non-invasive growths. Treatment involves removal of the tooth and bone around the roots, minimal margins are required. Acanthomatous ameloblastoma is another variable of epulides and is more locally aggressive and invasive. Clinical signs include gingival swelling around the affected tooth. Diagnosis is based on biopsy results. Treatment involves surgical excision with complete removal of the periodontal ligament within margins that should be 1-2 cm. Acanthomatous ameloblastoma also responds to radiation therapy. Both treatment options provide a very good prognosis.

Melanoma, squamous cell carcinoma, fibrosarcoma or osteosarcoma are oral tumors with variable metastatic characteristics. Imaging with biopsies is important for determining the prognosis and for treatment options.

Tooth Resorption

Also Known As…

Cervical line lesions, Neck Lesions

Resorptive Lesions, Feline Osteoclastic Resorptive Lesions

Tooth resorption; formerly known as resorptive lesions, cervical line lesions, feline osteoclastic resorptive lesions and neck lesions are commonly seen in as many at 30-75% of cats. The exact mechanism of cause is not understood, however, something triggers the destruction of the tooth, usually beginning on the root surface just below the gumline and advancing coronally.

Clinical signs include localized gingivitis and/or hypertrophy, tooth sensitivity (chattering), loss of appetite and visible tooth destruction.

Diagnosis is based on clinical signs and dental radiographs, looking for lytic destruction of the root and/or crown. Dental radiographs provide information that determines the technique of extraction of the tooth. If radiographs reveal loss of detail of the root and canal structures, complete extraction of the root is un-necessary. If there are signs of infection of the root system the complete root must be extracted.

Enamel Defects

Damage to the enamel that occurs during the development of the tooth is either enamel hypoplasia or hypomineralization. Generalized systemic infections such as viruses like distemper or parvovirus or even a

febrile episode can affect the enamel formation.

Clinical signs include soft chalky enamel that flakes easily or areas of enamel loss with staining of the underlying dentin. Dental radiographs should be obtained to evaluate the health of the tooth and for normal root development.

Treatment involves removing the damaged, soft, flaky enamel and smoothing the remaining enamel edges, followed by sealing the enamel and exposed dentin with a bonding agent or flowable composite to lessen the roughness of these damages areas, making them less plaque retentive.

Retained Deciduous Teeth

Retained (or persistent) deciduous teeth are a common problem, especially in small breeds of dogs. The best rule of thumb is “there should never be two of the same type tooth in the same hole”. Problems associated with retained deciduous teeth include bad breath, periodontal disease problems, orthodontic or bite problems and pain.

Treatment involves extraction of the persistent deciduous tooth, as soon as possible. Typically, the deciduous tooth is smaller and more pointed than the adult that follows it. When in doubt, a dental radiograph can help differentiate the differences. Generally, the upper incisors and canines erupt rostral to the deciduous tooth while the lower canines erupt lingual to the deciduous canine.

Gingival Hyperplasia

Gingival Hyperplasia can occur as a generalized condition or more localized. It is characterized as an overgrowth of the gums, sometime so severely that it completely covers the tooth. Some breeds predisposed include Boxers, Bulldogs and Staffordshire Bull Terriers. Another predisposing factor are certain drugs, specifically Phenytoin, Cyclosporin and (in humans) pregnancy.

Treatment involves cutting back the overgrowth to a more normal level. It is important to biopsy representative areas of the affected areas. Gingivectomy is commonly performed with “cold steel” to remove the bulk of the tissue, followed by contouring with a multi-fluted bur on the

highspeed handpiece. It is important to maintain a two millimeter minimum biologic width of attached gingiva. The fluted bur helps to control hemorrhage along with digital pressure and topical astringents. Electrocautery should be used with caution to avoid thermal damage to the underlying bone.

Oro-Nasal Fistula

An oronasal fistula is defined as a communication between the oral and nasal cavities. It is usually secondary to periodontal disease and most commonly found on the palatal aspect of the maxillary canine teeth. It can result from trauma to the maxilla or failure of the closure of an extraction site. ONF's are commonly seen in dachshunds, shelties, collies and schnauzers.

Clinical signs include chronic sneezing and nasal discharge that can be unilateral or bilateral. Diagnosis is based on probing the periodontal defect, the presence of blood in the nostril after probing or flushing saline into the defect and seeing the saline in the nostril. Closure of extraction sites should be made without tension on flaps to improve success.

Suborbital Facial Swelling

Sudden facial swelling below the eye is a common presentation to the general practice. Often a draining tract accompanies it either on the face or intraorally. One of the most common reasons for the swelling is an abscessed tooth-the upper 4^{th} premolar or the 1^{st} molar. Other conditions to rule out are cysts and oral growths. Don't be fooled into thinking it is an insect sting and fail to check the teeth.

Diagnosis is based on the clinical signs and dental radiographs. If a fistula is present, contrast may be used to assist in the diagnosis. Usually a dental radiograph will differentiate which tooth is involved or is something more such as cancer present. Treatment is based on the differential diagnosis- an abscessed tooth should be extracted or have a root canal, cysts should be excised, including careful removal of the cyst lining. Tumors should be biopsied to determine the best treatment plan. Prognosis varies based on the diagnosis.

Base Narrow Mandibular Canines

BNMC teeth are a condition where the lower canine teeth traumatize the hard palate. This can result from a type III malocclusion resulting in a short mandible or from retained deciduous teeth. Often in puppies that are head shy, BNMC are present and when we look the pup in the eye we lift the chin, pressing the teeth into the hard palate causing pain.

Left untreated, this condition can progress to an oronasal fistula as well as attrition of teeth making contact with each other. Treatment may include orthodontic movement, crown reduction or extraction.

Periodontal Disease

Certainly, periodontal is the most common “disease” of dogs and cats. Studies have shown 70-80% of dogs and cats over 3 years of age have enough plaque and tartar buildup to justify a complete dental cleaning and evaluation. Dental radiographs and probing are essential to fully evaluate periodontal disease. In general, single rooted teeth become mobile with more than 50% bone loss while multiple rooted teeth may remain stable. Teeth with greater than 50% bone loss are typically extracted because it is unlikely the tooth will be a long term survivor and may cause discomfort.

DENTAL RADIOLOGY
Techniques and Interpretation

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Taking and interpreting dental radiographs is a skill that requires practice. In time your speed of taking them will improve-practice, practice, practice. The more radiographs you take, the quicker you will become at getting the proper positioning on the first try.

An excellent reference for interpretation dental radiographs is “Atlas of Dental Radiography in Dogs and Cats by Gregg A. DuPont and Linda J. DeBowes, published by Saunders-Elsevier. This book contains chapters on techniques, normal radiographic anatomy and pathology in both dogs and cats.

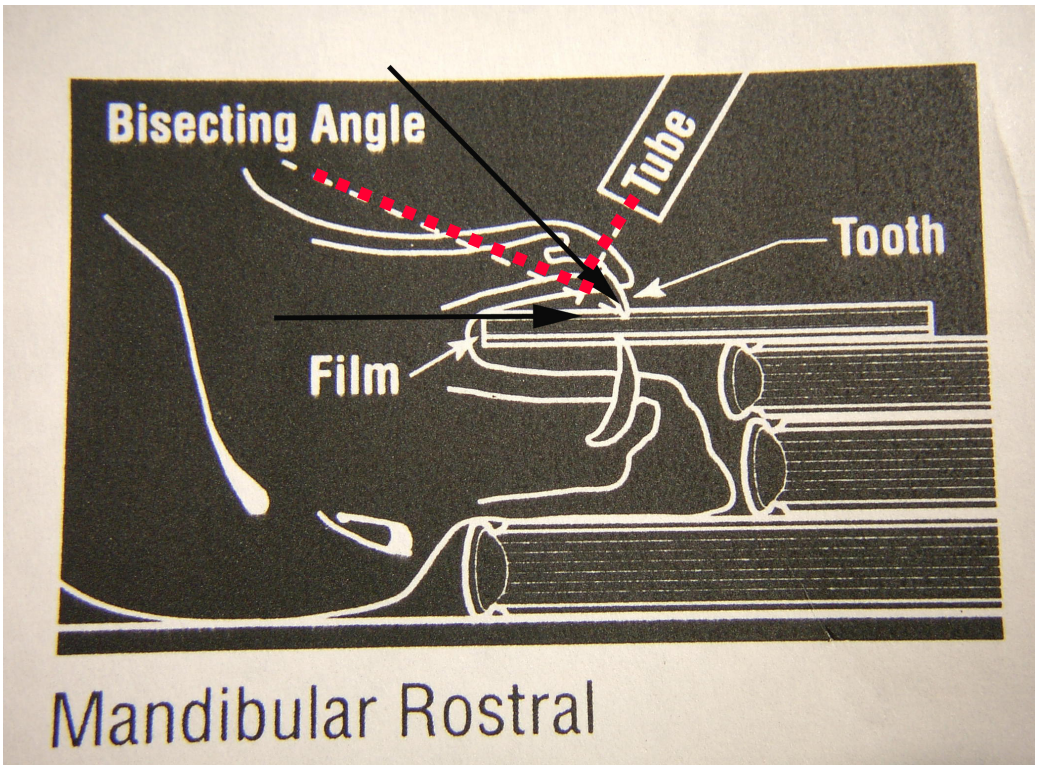
Dental RadiographyTechniques

Parallel

Film parallel to tooth and root
Used with mandibular premolars and molars
Film size and technique works for very small animals, especially with limb injuries

Bisecting Angle

Apply that geometry you despised in high school
Allows accurate image of incisors, canines, maxillary premolars and molars



Interpretation of dental radiographs begins with proper orientation. They should be arranged in a manner similar to the normal anatomy of the mouth. There are 2 common ways: the most common is "facing the face" in which the images are arranged as if you are looking at them from outside of the mouth. With this method the images of the left side are on the right and vice versa. The other method is "upon the tongue" in which the images are arranged as if you are sitting on the tongue, looking out.

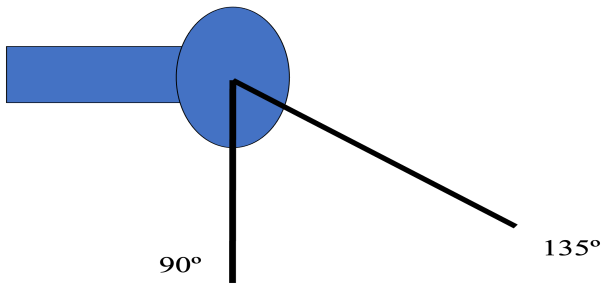
Another factor in the interpretation of dental radiographs is being familiar with the number, normal shape, number of roots and anatomy of the teeth. Keep a dog and cat skull handy for reference as well as for client education.

The dental formula is as follows:
Dog –Deciduous-Incisors 3/3, Canines 1/1, Premolars 3/3=28
Adult- Incisors 3/3, Canines 1/1, Premolars 4/4, Molars 2/3=42
Cat-Deciduous-Incisors 3/3, Canines 1/1, Premolars 3/2=26
Adult- Incisors 3/3, Canines 1/1, Premolars 3/2, Molars 1/1=30

In general, the number of roots of dog and cat teeth are as follows:
Single Roots-incisors, canines, 1st premolars, last lower molar
Double roots-upper PM 2 and 3, lower PM 2, 3 and 4, lower M 1 and 2
Triple roots-upper PM4, upper M1 and 2

Verstraete Study: Retrospective Study-Justification for Dental Rads
Value of radiographs with clinical findings present
Conformational only Dog (24.3%) Cat (13.9%)
Additional findings Dog (**50.0%**) Cat (**53.9%**)
Clinical essential findings Dog (22.6% Cat (32.2%)
No value Dog (3.1%) Cat (0%)
Value of radiographs w/no clinical findings present
Incidental radiographic findings Dog (41.7%) Cat (4.8%)
Clinically important findings Dog (**27.8%**) Cat (**41.7%**)
No value Dog (30.5%) Cat (53.6%)

Radiation Safety
Inverse Square Law:
If "x" amount of radiation is at 1 meter then at 2 meters
it is ¼ x . Six feet from the tube head is a reasonable distance to maintain
AND 90-135º from Tube head is safest to be to avoid scatter



Room entrances-be sure to set up a system to let employees know when rads are being taken and maintain the 6 foot distance.

SLOB Rule (Same Lingual Opposite Buccal):

- Used to help identify the location (buccal or lingual) of an object or lesion on a dental radiograph
- Requires 2 radiographs
- Shift tube head in 2nd shot noting the direction of shift and of the lesion
- If the lesion moves in the same direction as the tube shift it is lingual, if it moves in the opposite direction it is buccal.

Indications and Interpretation of Dental Radiographs

Attrition/Abrasion Wear-excessive wear to the crown of the tooth can lead to changes in the roots.

Fractured Teeth-Open pulp or not rads help choose treatment options

Missing/Un-erupted teeth-looking for un-erupted teeth or root tips that could become cystic or abscessed

Dentigerous Cyst-an unerupted tooth that causes cyst formation that can be very damaging to bone by cyst expansion

Radicular Cyst- cyst associated with the root of a tooth

Odontoma- Compound-organized, tooth or tooth-like structures
Complex-unorganized material
Either can be destructive

Facial/Sub-orbital Swelling-most commonly an abscessed tooth but must rule out cancer and cysts

Periapical Abscess-infection seen as lytic areas of bone at the tip of teeth

Missing teeth/retained roots-confirm entire tooth and root is missing/removed. Roots, if present can become abscessed.

Periodontal disease-evaluate bone around teeth

Supernumerary (Extra) Roots-ID their presence, especially for extractions
Supernumerary (Extra) Tooth-confirm anatomy if extracting

Dens Indente-"tooth within a tooth"-malformed tooth often become abscessed

Gemination and Fusion tooth-involves crown and root development

Convergent roots-malformed roots often lead to need for extraction

Dilacerated roots-roots with bends or turns in their anatomy-helpful to ID because they are more difficult to extract

Tooth Resorption: "aka" cervical line lesions, resorptive lesions, neck lesions, FORL-feline osteoclastic resorptive lesions
Type I-normal root structure visible
-perio or endo disease maybe present
Treatment-extract completely
Type II-root resorption
-normal root structure not visible
Treatment-crown amputation

Abnormal Roots-Concrescence-roots appear to have fused together

Enamel Hypoplasia-abnormal development of enamel, root development may be affected

Hypercementosis-over development of cementum on the root, usually appears as an enlarged, bulb at the apex of the root

Jaw Fractures-dental rads allow isolation of fracture to more easily evaluate and treat

Economics of dental radiology (prices may vary)

Assume:

5000 animals over 3 years of age
75%“need” COHAT (Complete Oral Health Assessment and Treatment)
75% of 5000 = 3750
BUT, we only do:
2 Oral COHAT’s per weekday = 520 / year
Average of 2 dental rads per animal = 1040 films / year
Charge $20 / film = $20,800 income / year

Costs:

Dental x-ray machine	$4,000- $ 5,000
Digital dental software +/-computer	$6,000 - $15,000
TOTAL	$10,000 - $20,000

Dental X-ray Techniques

Indications:

1. Periodontal disease - any areas of gum recession, furcation exposure or gingival pockets. Extract if greater than 50% bone loss
2. Broken or worn teeth: Abrasion or attrition can cause pulp exposure without visible signs. Look for signs of root tip infection.
3. Discolored teeth: Pink, purple or gray color indicated dying or dead teeth (93% of them). Compare pulp chamber size and look for signs of root tip infection
4. Enamel defects: look for root changes-there may be deformities or periapical lucency
5. Suborbital swellings: Rule out cancer, abscess, cyst. Look for root tip infection or cystic teeth
6. Deciduous tooth extractions: confirm adult tooth present prior to extraction, also helps plan the extraction
7. "Resorptive lesions": Characterize tooth health, helps to decide extraction method – extraction vs. crown amputation
8. Oral tumors: Look for bone involvement, plan/evaluate margins.
9. Pre- and post-extraction: Help gauge difficulty of extraction and plan extraction method. Identify potentially difficult to extract teeth. Insure all roots were extracted, bone edges smooth (for better healing)
10. Missing teeth: Evaluate for un-erupted teeth (potential cysts) or retained roots (potential abscesses)
11. Oral surgery: Oral fractures or margins for oral tumor surgery
12. Full mouth series: elective service for your clients- make sure all teeth, roots and bone appear healthy
13. Small mammals, exotics-injured limbs, tails, etc.

The challenge:
For one month track the number of dental cleanings you perform as well as the number of dental x-rays you would have taken based on the above indications. Then, do the math and see how quickly you can pay for adding dental radiology to your practice.

DATE	# Dental cleanings	X-ray indicated

Focused cardiac ultrasound in cats

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Abstract:

Cardiac ultrasound and echocardiographic scanning tips will be provided to improve your ability to get a diagnostic scan. The pros and cons of a focused cardiac ultrasound versus an echocardiogram will be discussed. The goal is to make you more comfortable interpreting radiographic and echocardiographic findings in cats suspected of having underlying heart disease.

Keywords: cardiac ultrasound, feline, scanning tips, cardiomyopathy

Focused cardiac ultrasound:

- Focused cardiovascular ultrasound examination is performed as an adjunct to the physical examination as a screening tool for heart disease.
    - Is your patient in respiratory distress due to congestive heart failure or feline respiratory disease?
- Used as a screening tool but lacks detailed information on heart anatomy and function and may fail to identify all cardiac abnormalities.

- Overlap may exist between normal cardiac anatomy and early or mild cardiomyopathy (CM) on ultrasound, especially in older cats. Equivocal findings will prompt serial monitoring to evaluate for the progression of more severe disease (*watch for an increase in the left atrial size).

Clinical indications for Focused cardiac ultrasound:

- Cats with clinical signs attributable to heart disease dyspnea, collapse, +/- dragging a limb.
- Cat in need of or currently receiving medical treatment that could result in cardiac complications such as steroids, fluid therapy, sedation, or general anesthesia.
- Any cat for screening for occult CM as part of a routine wellness exam.

Rule-outs before a diagnosis of cardiac disease

- Rule out underlying causes of hypertrophic phenotypes, such as hyperthyroidism and hypertension, before diagnosing idiopathic CM.
- Volume status can alter cardiac morphology.
    - Dehydration will create pseudohypertrophy. The left ventricular chamber is decreased in size with apparent thickening of the left ventricular (LV) wall. These changes can mimic the appearance of hypertrophic cardiomyopathy without enlargement of the left atrium.
    - Volume overload: Avoid evaluating the cat's heart while receiving fluid therapy, long-acting steroids, or anemia because these medications/conditions will cause an increase in the left ventricular chamber size and the left atrial size.

- Serial cardiac ultrasound and TFAST could be utilized to monitor volume overload from IV fluid therapy. An increase in the left atrial size and an increase in lung interference are hallmarks of fluid overload.

Cat positioning for cardiac ultrasound/echo

- Lateral recumbent, sternal, standing, or on the operator's lap.
- Sedation has to be on their approved list of drugs if submitting the study to a cardiologist.
- IDEXX-approved sedation protocols include:
  - Gabapentin 2-3 hours before the exam
  - Butorphanol
  - Butorphanol plus midazolam
  - +/- Alphaxalone

My scanning advice:

- Attempt to learn to perform a portion of the exam while the patient is in sternal recumbency. All the right-side images can be obtained while in the sternal position. If the heart is enlarged, the left-sided scans can also be easily obtained while the patient is sternal.
- Cardiac table is still helpful to remove the slot so the probe can be placed perpendicular to the body just above the sternum when scanning the right side.
- Keep it quiet (whisper), "mood" lighting for the best cat behavior, door closed (low to no traffic), and away from barking dogs if possible.

Extracardiac structures that will aid in the diagnosis of cardiac disease:

- You must look for pericardial, pleural, and abdominal effusions and lung interference (B-line artifacts). You may need to perform a global FAST of the thorax and abdomen to find evidence of fluid/lung interference.
    - The presence of scant to mild pericardial effusion with heart disease can indicate left-sided congestive heart failure.
    - Pleural effusion is commonly seen with left-sided congestive heart failure, unlike in dogs.
    - It can be hard to visualize a small volume of pericardial effusion if the cat has concurrently had pleural effusion.

LA size is the most critical measurement in dyspneic cats:

- Normal left atrium at the heart base, measured from a right parasternal short axis view, should not be >1.5 cm.
- Moderate to severe left-sided heart disease typically accompanies left atrial enlargement.
- Look for "smoke" in the enlarged left atrium/auricle, which will have a greater risk of developing left auricular thrombus and aortic thromboembolism.

LA/Ao ratio is right parasternal short axis view:

- To find this image, a cat can be sternal or recumbent. Aim the probe perpendicular to the thoracic cavity to get a mushroom view. From the mushroom room, tip the probe towards the shoulder by dropping the handle towards the table, to visualize the aorta and the left

atrium. Be careful not to measure the pulmonary artery dorsal to the left atrium. Place your index finger on the sternum, which keeps the leg forward and stabilizes the probe.

- When clinical signs are present, the ratio of the left atrium/aorta diameter >2.0 is suggestive of left-sided heart failure in cats. Alternatively, if the left atrium is normal in size and the TFAST shows dry lungs, the cat's clinical signs are less likely to be due to left-sided heart failure.
- **DON'T pull the cat's leg forward! You will never win a tug-of-war with a cat.**

The scanning trick to obtaining a 2D image of the right and left ventricle:

- Right parasternal short-axis view of RV/LV. Perpendicular to the thoracic wall (no tipping) to obtain this image. Called the "mushroom" view. Without the right heart chamber offsetting the septum, you may accidentally measure the right ventricular free wall and septum as one structure. If you don't see a half-moon of the right ventricular chamber, move cranial one intercostal space +/- dorsally.

Assessment of RV/LV for Focused Cardiac Ultrasound:

- Goals of RV/LV short-axis view measurements from 2D images only:
    - Left ventricular chamber size, contractility, and wall thickness.
    - Critical measurements are wall thickness in diastole.
    - Fractional shortening: LVIDd-LVIDs/LVIDd typically 45-55% in unsedated cats, <35% would be concerning for cardiac dysfunction due to DCM or end-stage HCM.

Challenges of Assessment of Focused Cardiac Ultrasound:

- Challenges of RV/LV or mushroom view:
  - Are the LV wall alterations due to positioning or real?
  - The right heart measurements have not been established. However, if the right heart is noticeably enlarged, this may indicate RCM or ARVCM.
- Disease detection from cardiac ultrasound:
  - LV wall thickness (interventricular septum and left ventricular free wall in diastole) ≥6.0 mm. If you find LV wall thickness in the normal range in diastole with increased LA, this could still be RCM or UCM.
  - Enlarged papillary muscles (**this is very subjective**)
  - Left ventricular chamber decreased in systole (decreased volume detected). Be careful of volume-depleted patients or when the heart is hypercontractile when the nervous.

Longitudinal view of the left atrium/left ventricle and left ventricle:

- A right parasternal long-axis view of the left atrium can be obtained by rotating the probe 90 degrees from the short-axis view of the RV/LV. No tipping needs to be perpendicular to the thoracic wall.
- Less frequent use of these longitudinal views to evaluate chamber size, wall thickness, contractility, and more highly variable measurements.

Left ventricular outflow tract:

- Left ventricular outflow tract. Obtain image from right parasternal long axis view tipping slightly towards heart base. The goal is to look for focal thickening of the interventricular septum that causes LVOT obstruction. M-mode of the mitral valve can document systolic anterior motion (SAM).

Feline cardiomyopathy from the ACVIM 2020 consensus: All except ARVCM will typically present with variable enlargement of the left atrium.

- **Hypertrophic (HCM)-** Diffuse or regional left ventricular hypertrophy with normal to decrease in size of the LV chamber, variable left atrial enlargement, and diastolic dysfunction.
    - **Obstructive-** myocardial hypertrophy of the interventricular septum obstructing the left ventricular outflow tract results in functional subvalvular aortic stenosis.
- **Restrictive (RCM)-**myocardial form with LV dimensions and wall thickness in the normal range with left atrial or biatrial enlargement. Hypokinesis or alterations in echogenicity may be seen in the left ventricular wall. Endomyocardial form scar that occurs between the interventricular septum and free wall with LV apical thinning and left atrial or biatrial enlargement.
- **Arrhythmogenic right ventricular cardiomyopathy (ARVCM)-**arrhythmia present, severe right atrial and ventricular dilatation, RV systolic dysfunction, and RV wall thinning. The left heart may be affected. These cats may present with radiographic signs of right-sided congestive heart failure (pleural effusion, peritoneal effusion).

- **Dilated (DCM)-** left ventricular systolic dysfunction with a progressive increase in ventricular size, normal to reduced LV wall thickness, and atrial dilatation. The left ventricular chamber size increased with a drop in the fractional shortening ≤ 28%.
- **Unclassified cardiomyopathy (UCM)-** echo changes don't fit into other categories.

Echocardiogram rules of thumb:

- Left atrial size no greater than 1.5 cm at the heart base obtained from the right parasternal short axis view. Less than 1.6 cm when measured from the right parasternal long-axis view.
- The interventricular septum and left ventricular free wall abnormally thickened if greater than 0.6 cm in diastole.
- Fractional shortening: typical cat ranges from 45-55%, can be elevated in early disease or due to patient excitement (repeat during the same exam if patient calms down), decreased in a failing heart.
- Rule of thumb for the left ventricular chamber in diastole 1.5 cm and systole .9 cm.
- EPSS in normal cats most <0.2 cm.

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FELINE LUNG DISEASE

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Abstract

Thoracic radiographic studies are likely the most common site imaged in veterinary medicine. The radiographic appearance of lung disease can be challenging in our feline patients. An overview of the lung patterns with examples of radiographic findings in cats with lower airway disease will be discussed. Computed tomography is more sensitive in the detection of chronic lower airway disease and a few case examples will be incorporated into this presentation.

Keywords: thoracic radiographs, lung disease, feline, computed tomography

Where to start?

Diagnosis of lung disease requires obtaining tangential radiographic views with appropriate positioning and technique. A dorsoventral position is safer and less stressful for patients with pleural effusion before acquiring a lateral projection. Minimal restraint is required for the dorsoventral view if the head is positioned relatively straight between the front limbs. Sedation can cause hypoinflation and atelectasis of the lung and alter the cardiac size.

Questions to ask?

- Are the lungs normal or abnormal?
- Is the abnormal opacity increased or decreased?
- Is the affected lung increased or decreased in size?
- What is the distribution of the abnormal lung? Cranioventral, craniodorsal, diffuse, lobar, mixed, or focal?
- Are there radiographic signs that are pathognomonic for disease?
- Is there evidence of pleural or thoracic wall disease?
- General questions: size, shape, position, density, margination, and number

Patterns of Disease

Alveolar pattern

An alveolar lung pattern is due to fluid/cellular accumulation within the alveoli and may form air bronchograms, a lobar sign, fluffy coalescing densities, and border effacement/silhouette sign. Alveolar patterns may be focal, multifocal, involve one lung lobe, or generalized. Although air bronchograms and a lobar sign are commonly associated with alveolar pattern, sometimes neither is present. An intense lung disease is classified as alveolar by excluding the other lung patterns. The most likely cause is pneumonia, pulmonary edema, and hemorrhage. The distribution of the lung changes, along with history and presenting clinical signs, will assist in determining the cause. In cats, generalized or multifocal alveolar disease with enlargement of the affected lobe should be suspected for primary or metastatic tumors.

Location: ventral (aspiration pneumonia); perihilar (cardiogenic edema); caudodorsal (non-cardiogenic edema), variable (pulmonary hemorrhage), neoplasia (lobar distribution), atelectasis (ipsilateral mediastinal shift)

Pneumonia

Pneumonia (bacterial) in cats is less common than in dogs but usually infectious. The right middle and cranial lung lobes are most commonly affected. Mycoplasma is a common organism found in lower respiratory tract infections. A ventral distribution of an increased pulmonary opacity is more common when inhaled/aspiration. The lung pattern can be alveolar, although a mixed pattern bronchointerstitial can also be present.

When the nodular margins are indistinct, with hazy or blurred margins, the differentials should include fungal granuloma or parasitic disease. Parasitic pneumonia due to *Aeleurostongylus* can lead to an interstitial, bronchial, or miliary nodular pattern with patchy alveolar infiltrates. The earliest changes are thickening the bronchial wall with ill-defined pulmonary nodules. *Paragonimus kellicotti* infections result in solitary or multiple ill-defined soft tissue nodules containing air within the pulmonary parenchyma. Verminous pneumonia is induced by worms residing or migrating through the lower airways (e.g., *Capillaria aerophilic*).

Fungal pneumonia due to histoplasmosis or blastomycosis can have a variable radiographic appearance with miliary nodules, ill-defined pulmonary nodules, or an alveolar pattern.

Parasitic pneumonia from *Toxoplasma gondii* is common in acute diseases. The thoracic radiographic findings include random, diffuse interstitial to patchy alveolar infiltrates.

Atelectasis

Collapse of the lung lobe results in an alveolar pattern. When the air is not replaced, this results in a loss of lung volume. The mediastinal shift toward the side of lung collapse is the key to identifying atelectasis. The affected lung may have a decrease in volume, triangular with a board base, and an increase in lung opacity with an alveolar pattern. Atelectasis can be transient due to prolonged recumbency or sedation. Obstruction of the airways can occur due to mucous, foreign body, or masses. It may not be possible to distinguish between atelectasis alone and a combination of atelectasis and alveolar disease on thoracic radiographs.

Vascular lung pattern

On the lateral projections, the cranial lobar artery and vein should be similar in size for each set of vessels. On the VD view, the caudal pulmonary vasculature should not exceed the width of the 9th rib. The pulmonary vessels will not be equally enlarged in patients with cardiac disease. Don't forget to evaluate the pulmonary arteries overlying the cardiac silhouette for evidence of enlargement (e.g., heartworm disease). Pulmonary venous congestion will precede the development of left-sided congestive heart failure. However, an increase in only one set of lobar arteries and veins may be seen with left-sided heart failure. Decreased pulmonary artery and vein size should raise suspicion for volume depletion.

Heartworm Disease

In cats, the cardiac silhouette typically appears normal. Although the main pulmonary artery may be enlarged, its more medial location prohibits identification on

survey radiographs. The pulmonary parenchymal changes associated with heartworm disease are variable, with focal or diffuse interstitial to a bronchial pattern, alveolar infiltrates, and enlarged pulmonary arteries. The pulmonary arterial changes may resolve over time with the persistence of a bronchointerstitial lung pattern. The right caudal lobar artery may be more commonly affected and best seen on the DV/VD view.

Unstructured interstitial pattern

An increase in interstitial opacity with blurring of the vascular margins is the hallmark of this pattern. The increased opacity can be due to the proliferation of fluid or cellular infiltrates or fibrous tissue. An interstitial lung pattern can be artifactually caused by underexposure, hypoinflation of the lungs due to sedation, and the body habitus (obesity). An increase in interstitial lung pattern can be seen due to aging, pulmonary fibrosis, neoplasia (lymphosarcoma, mammary gland carcinoma), and diseases in transition such as pulmonary edema, hemorrhage, pneumonia, and thromboembolism. Pulmonary edema typically begins with a hazy and patchy distribution of interstitial pulmonary infiltrations and can progress to alveolar infiltrations.

Bronchial

A bronchial pattern develops when cellular or fluid infiltrates are associated with the bronchial wall. When the bronchial markings appear to thicken and extend into the periphery of the lung, a bronchial lung pattern is identified. A bronchial lung pattern can be seen as an aging change in the hilar region. The bronchial walls will appear thickened, creating end on donuts and longitudinally as prominent paired lines or tram lines. The most common causes of a bronchial pattern include allergic airway disease, infection (bacterial or parasitic), or chronic irritants.

Chronic bronchial disease may present with lobar collapse, pulmonary hyperinflation, rib fractures, and bronchial mineralization.

Feline lower airway disease

This disease process likely includes feline asthma and chronic bronchitis. The bronchiolar disease is now well recognized in computed tomography studies. Bronchiolar abnormalities involve small airways <2 mm in diameter and cannot be evaluated on thoracic radiographs. Rib fractures may result from coughing/dyspnea episodes.

Feline asthma is a hypersensitivity reaction to eosinophilic airway inflammation and airway remodeling. Thoracic radiographs show an increase in bronchial markings with visualization into the periphery. Some cats may have flattened or tenting of the diaphragm (hyperinflation) and collapse of the right middle lung lobe (due to atelectasis and mucous trapping) or less commonly affects the caudal subsegment of the left cranial lung lobe. The right middle lung lobe will appear relatively homogeneous opacity and maybe triangular. A mediastinal shift towards the collapsed lung may be noted. Pulmonary hyperinflation likely results from air trapping secondary to chronic airway disease.

Chronic bronchitis is due to previous airway insults and a neutrophilic inflammation found on BAL. Chronic bronchitis is believed to be due to earlier lung insults, resulting in permanent damage to the lower airways. Chronic bronchitis can present with the bronchial pattern on radiographs. Bronchial wall mineralization is more common in cats with chronic bronchitis. There is hypertrophy of the mucosa with an increase in mucous production. Bronchiectasis and bronchomalacia occur secondary to

long-standing inflammation and are irreversible. Bronchiectasis in cats, the bronchi are diffusely dilated without tapering. Broncholithiasis is a pathologic condition when mineralized material is present within the lumen of the bronchi and maybe seen in cats with chronic lower airway disease. Respiratory distress occurs due to excess mucous secretions.

Structured (Nodular) interstitial pattern

Well-defined solitary or diffuse nodular structures with well-defined smooth margins include neoplasia, pulmonary abscess, traumatic pneumatocele, hematoma, or cyst. In cats, a primary neoplastic process includes carcinomas, which can appear as a large solid mass, cavitary mass, or diffuse disease. Central mineralization and cavitation of primary pulmonary neoplasia are common findings in cats. Metastatic neoplasia is often poorly marginated and irregularly shaped compared to metastatic nodules in dogs (e.g., mammary gland neoplasia). Primary pulmonary neoplasia in cats has been associated with pulmonary adenocarcinoma, pulmonary squamous cell carcinoma, and bronchogenic carcinoma.

Pleural effusion

Many pleural effusions are bilateral due to communications between both sides of the thorax. Radiographic features include retraction of the lung lobes from the thoracic wall. The presence of interlobar fissures, rounding and separation of the lung margins, lack of visualization of the heart, mediastinal widening, increased lung opacity, and dorsal deviation of the trachea. On the lateral view, the lung margins have a scalloped appearance. Don’t confuse the separation of the dorsocaudal lung from the spine from the psoas minor muscle as fluid. The position of the carina on the lateral view will help estimate the size of the cardiac silhouette. If the carina is at the same level as the trachea, cardiac disease should be considered. When a mediastinal mass

and pleural effusion are suspected, the cranial lung lobes may be retracted more caudolaterally on the DV/VD view. The cardiac silhouette may be displaced caudally with a mediastinal mass.

Causes of pleural effusion: Cardiac disease, mediastinal masses, diaphragmatic hernia, idiopathic (chylothorax); exudative (FIP), hypoproteinemia, hemorrhagic or neoplastic effusions

Pneumothorax

Air is present within the pleural space resulting in lung lobe retraction, partial collapse of the lung lobes, increased lung opacity, and separation of the cardiac silhouette from the sternum. Typically, pneumothorax is bilateral in distribution.

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LYMPHOMA AND ITS MANY DISGUISES IN CATS

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Abstract:

Lymphoma is one the most common neoplasia in cats, accounting for up to 30% of all feline malignancies. An overview of imaging findings from the tip of the nose to the tip of the tail will provide a comprehensive pictorial of the common sites and the appearance of lymphoma. In addition, contrasting examples of benign or other malignant processes that can mimic lymphoma will be included in this presentation.

Keywords: lymphoma, pulmonary, gastrointestinal, mediastinal, nasal, renal

Lymphoma (LSA) is one of the most common neoplasia in cats. Viral factors such as feline leukemia virus (FeLV) have a direct role in tumorigenesis. FeLV was more commonly associated with lymphoma cases in the 1960s-1980s. Currently, FeLV plays only a minor role in LSA cases. Feline immunodeficiency virus (FIV) has an indirect role due to the immunocompromise of the cat. The FeLV status plays a role in younger cats (up to 3 years of age) with a higher incidence of mediastinal and spinal forms. In FeLV-negative cats, the onset of lymphoma in older cats is between 7-8 years of age. Dietary modifications in the last 20 years

seem to parallel an increased incidence of intestinal lymphoma, although no direct link has been proven.

The prognosis for lymphoma is related to remission vs. partial remission, stable vs. progressive disease, and FeLV/FIV status. Nasal and small-cell gastrointestinal forms of lymphoma have a better prognosis.

Pulmonary

Pulmonary lymphoma is rare in cats. Variable lung patterns have been found. Some references have described the presence of pulmonary nodules or masses.

Alimentary/gastrointestinal is the most common form seen in older cats. Lymphoma may be confined to the gastrointestinal tract +/- stomach. Alternatively, the intestinal tract, mesenteric lymph nodes, liver, and spleen can be infiltrated. The involvement in the small intestines can be diffuse or solitary.

Gastric neoplasia

Gastric lymphoma is the most common neoplasia, followed by adenocarcinoma or leiomyosarcoma. Large cell lymphoma is the most common type found in the stomach. The median survival time is six months.

Radiographic imaging findings include thickening of the stomach wall with noticeable distortion of the gas bubble. In a few cases, the interface with the gas may outline the soft tissue mass. Mineralization within the gastric infiltrations can occasionally be seen.

On ultrasound, the upper limits of normal gastric wall thickening in cats are 2-4 mm. In cats with gastric lymphoma, there will be focal or diffuse thickening of the gastric wall or altered

echogenicity, most anechoic/hypoechoic, often with destruction of wall layering, and can be associated with gastric ulceration. Regional lymph nodes may also be enlarged, rounded, and anechoic/hypoechoic.

Fine needle aspiration of the gastric wall and regional lymph node(s) is the best way to obtain a cytologic diagnosis.

Small intestinal diffuse

The most common site (50-80%) primarily affects the jejunum and ileum. Odds are greater for LSA if the cat is greater than nine years old with muscularis thickening. Typically, the diagnosis is small cell lymphoma in cats. An intestinal biopsy may be needed when only diffuse intestinal thickening is present. The primary differential diagnosis for lymphoma is inflammatory bowel disease. If the owner can afford treatment and the cat can be handled, this form of lymphoma has a high treatment response rate with a median survival time of 1.5-3.0 years.

Radiographic findings in normal cats: In nonfasted cats without GI disease, greater than 25% of the small bowel can contain gas. In fasted and unsedated cats, gas within the small bowel is rare.

Radiologic rule of thumb: Small intestinal loops should not be greater than 2x the height of central L4 or endplate of L2 on lateral radiographic imaging. The ratio of the small intestine to >2.5 height of L2 was likely obstructed. The small intestines should not be greater than 12.0 mm in diameter.

Radiographic findings on survey images: No abnormalities may be noted on survey radiographs.

Ultrasound: The intestinal thickness is considered normal when <3.0mm (although the ileum may be slightly thicker up to 3.4 cm). On ultrasound, wall thickening with the

muscularis/submucosa, normal to loss of wall layering, reduced wall echogenicity, decreased local motility, regional lymphadenopathy, +/- peritoneal effusion, +/- organomegaly, an increased concern when muscularis layer is equal or greater to the mucosal layer.

Small intestinal Focal/Discrete gastrointestinal mass(es)

The clinical course is aggressive. The median survival time is approximately six months. The diagnosis is more likely to be intermediate to large cell lymphoma. The primary differential diagnosis for a focal intestinal mass is mast cell tumor or adenocarcinoma.

Imaging findings:

Radiographic: Survey abdominal radiographs may appear normal unless the focal mass causes an intestinal obstruction.

Ultrasound: On abdominal ultrasound, transmural wall thickening is present with loss of wall layering +/- lymphadenopathy.

Mediastinal

Mediastinum can be divided into three parts. The cranial mediastinum's most common mass is due to lymphoma, thymoma, ectopic thyroid, or due to benign cysts. Sternal lymphadenopathy is due to an inflammatory or neoplastic process within the abdomen. Cranial mediastinal masses must be differentiated from pulmonary nodules in the same region. The middle mediastinal abnormalities include tracheobronchial lymphadenopathy, as seen with fungal disease or round-cell tumors. The caudal mediastinum occurs near the diaphragm. Hiatal hernia is usually dynamic and observed with a greater frequency on the left lateral projection. Subtly may be seen

on midline on VD/DV view. Other causes of increased soft tissue in the caudal mediastinum are associated with foreign bodies or neoplasia.

Lymphoma cases in the mediastinum were more likely to be solid, with equal numbers presenting as hyperechoic or hypoechoic. Differential diagnosis includes thymoma, cystic lesions, ectopic thyroid, and other types of neoplasms. Many thymomas are more cystic than lymphoma. Thymomas have been associated with esophageal dysfunction and acquired myasthenia gravis.

The diagnosis can be made by fluid analysis or aspiration. Intermediate to large cell lymphocytes are typically seen in cases with lymphoma. When a mediastinal mass is found in a young FeLV+ cat, there is a poor prognosis with a median survival time of 2-3 months. In older FeLV-cats, the survival time is similar to other sites.

Imaging findings:

Radiographic: Cranial mediastinal masses are the most common. Dorsal deviation of the tracheal and border effacement with the cardiac silhouette occurs with larger cranial mediastinal masses. The margins of the cardiac silhouette may be difficult to visualize due to the mediastinal mass and concurrent pleural effusion. The location of the carina caudally +/- dorsally will support the presence of a mediastinal mass. Widening of the cranial mediastinum may cause caudal displacement of the cranial lung lobes on the VD/DV view. Concurrent pleural effusion is commonly associated with mediastinal masses and may hinder the identification of the margins of the mediastinal masses.

Ultrasound: The classic appearance is a hypoechoic nodular mass with a well-defined echoic rim. Color Doppler may show variable blood flow to a mediastinal mass. Cytology will be needed for a definitive diagnosis.

Nasal

The presenting sign associated with nasal lymphoma includes nasal discharge, sneezing, stertor, facial deformity, decreased nasal flow, hyporexia, and an increased respiratory effort.

Nasal LSA accounts for 26-49% of nasal malignancies, followed by carcinomas, adenocarcinomas, squamous cell carcinomas, and sarcomas. Most nasal lymphomas are confined to the nasal cavity with only 20% having systemic involvement. Some cats may develop multicentric diseases later. Diagnosis involves staging with computed tomography and nasal biopsy. Nasal lymphoma is usually intermediate to high grade. The median survival time ranges from 1.5 to 3.0 years if both treatments (chemotherapy and radiation therapy) are utilized.

In a recent 2021 paper on nasal masses in cats, the CT findings with lymphoma included a mixed (permeative, expansile, and destructive) and expansile growth pattern (displaced the surrounding bone peripherally) and regional lymphadenopathy. Lymphoma was more likely to occupy the entire nasal cavity than rhinitis. Advanced imaging for staging of 17/35 cats was performed and identified pulmonary nodules (4), intrathoracic lymphadenopathy (2), and pleural effusion (1).

Renal

The incidence of renal lymphoma ranges from 7-30% and can be multicentric or confined to the kidneys.

In the older literature, there was a higher incidence of CNS involvement. The lower incidence of CNS involvement is due to a lower incidence of FeLV in our current feline population.

The renal size on radiographic images in older cats without signs of renal disease is 1.9-2.6 times the length of L2. In most older cats, the renal size is 2.0 times the length of L2.

Radiographic findings: Bilateral renomegaly with irregular margination

Ultrasound finding: Typically enlarged, irregular marginations, with a hypoechoic subcapsular rim. Focal or multifocal nodules or masses have also been reported. The subcapsular region is an accumulation of lymphoma and not fluid.

The differential diagnosis for renal lymphoma includes FIP, transitional cell carcinoma, undifferentiated malignant neoplasia, renal anaplastic carcinoma, or chronic active nephritis.

A fine needle aspiration of the kidney (outer rim) and cytology are needed for diagnosis. Renal lymphoma is usually large cell lymphoma. The prognosis is guarded.

Urinary bladder

Lymphoma affecting the urinary bladder in dogs and cats has been reported rarely. The differential diagnosis for bladder tumors is transitional cell carcinoma, followed by squamous cell carcinoma, adenocarcinoma, and undifferentiated carcinoma.

In this series of 3 dogs and one cat, urinary bladder lymphoma appears on ultrasound as a heterogeneous mural mass with a well-defined luminal–mucosal interface.

Adrenal glands

One case report in a cat found lymphoma in the cat with bilateral adrenal gland enlargement. You may want to consider lymphoma if there is bilateral adrenal enlargement.

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WHAT HAS THE AORTA BEEN TRYING TO TELL US ABOUT SYSTEMIC HYPERTENSION?

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Abstract:

Systemic hypertension (SH) is an insidious cause of target organ damage in our canine and feline patients. Human and veterinary literature provides clues about aortic remodeling in dogs and cats with SH. Aortic undulation and aortic knob formation will be discussed as a sentinel sign of SH in dogs and cats. Alterations in the size and shape of the three aortic cusps provide a reliable indicator of SH. Hopefully, recognizing aortic remodeling on thoracic radiographs and echocardiographic studies will provide earlier recognition, monitoring, and treatment for SH.

Keywords: Aortic remodeling, systematic hypertension, thoracic radiographs, echocardiogram, dog, cat

In canine patients, systemic hypertension can be seen in patients with diabetes mellitus, hyperadrenocorticism, acute or chronic renal disease, adrenal tumors, and associated with some medications (Palladia®, Proin®). SH in feline patients is typically found secondary to renal disease and hyperthyroidism. Idiopathic causes may account for up to 20% of cases in cats.

Systemic hypertension is currently classified as mild (150-159 mm Hg), moderate (160-179 mm Hg), or severe (greater than 180 mm Hg). Target organ damage (TOD), outlined by the 2018 ACVIM SH consensus statement, has listed the cardiovascular changes as concentric left ventricular hypertrophy, left-sided heart failure, and rarely aortic aneurysm. A minimal risk of target organ damage is thought to occur in animals with blood pressure under 150 mmHg.

Since the 1960s, uncoiling and dilatation of the thoracic aorta have been recognized on lateral radiographic studies in people with systemic hypertension. A bulge of the aortic arch/proximal descending aorta seen on the posteroanterior radiograph in people is referred to as the aortic knob. The aortic knob is considered target organ damage in people with SH. Echocardiographic aortic root dilatation and asymmetric dilation of the sinuses at the level of the aortic valves have been more recently identified as target organ damage in people with SH. Abdominal ultrasound and advanced imaging (computed tomography or magnetic resonance imaging) of the abdomen have been used to identify dilatation/aneurysm formation of the aorta secondary to systemic hypertension in people.

In canine patients, lateral thoracic radiographs showed variable aortic undulation and disproportionate enlargement of a portion of the aorta between the ascending and proximal descending aorta compared to the descending aorta cranial to the diaphragm. In dogs with SH, a ratio of the thoracic cavity caudal to the 3rd rib to aortic knob width from the ventrodorsal view was developed to account for the variability in the dog's sizes. The median ratio of the thoracic cavity to aortic knob was 3.4 in dogs with SH vs 4.1 in dogs with normal blood pressure. The asymmetric size of the three aortic cusps (>1.0 mm) strongly indicates SH in dogs. The ratio of the caudal abdominal aorta to the caudal vena cava is ~ 1:1 in unsedated canine patients with blood pressure in the normal range. The abdominal aorta may be increased in size relative to the

caudal vena cava in unsedated dogs with SH. The caudal vena cava can be decreased artifactually due to external pressure when scanning and volume depletion.

There is an overlap of radiographic and echocardiographic findings in cats with cardiomyopathy, thyrotoxic cardiomyopathy, and systemic hypertension, all having varying degrees of left ventricular hypertrophy. Identifying unique radiographic and echocardiographic parameters is needed to differentiate these diseases. Alterations in the size and shape of the aorta in cats with SH have been recognized in various case reports of echocardiographic studies and anecdotally noted as undulant or prominent aortic arches on thoracic radiographs. In contrast, a paper from 1993 deemed aortic undulation as an aging change in older cats without documenting normal blood pressure.

Echocardiograms were performed in all cats to rule out underlying cardiac diseases. Cats were assigned to the group with normal blood pressure if systolic blood pressure was less than 150 mmHg and to the SH group if it was over 150 mmHg. Seventy-six cats were included in each group for evaluation of the echocardiographic data. No differences were noted in the thickness of the interventricular septum or left ventricular free wall between the groups. The aortic diameter was significantly different between the groups. The average differences between the size of the three aortic cusps, in cats with normal blood pressure ranged from 0.15-0.25 mm. The aortic cusp size was considered altered when the differences in cusp size varied between ≥.5-3.5 mm. The aortic cusps were abnormal in size in 62/76 SH cats, 12/62 with ≥0.50 mm, and 50/62 at ≥1.0 mm differences.

Radiographic studies of the same cats were available for evaluation by two blinded reviewers for 46 cats with normal blood pressure and 49 cats with SH. The vertebral heart score was measured from the lateral projection and showed no difference between the groups. The

maximum distance of the aortic arch/proximal descending aorta to the spine and trachea on the ventrodorsal/dorsoventral projection showed significant differences between the groups. The best cut-off for detection of SH when measuring the aorta to the spine was 0.77 cm, a sensitivity of 84% and a specificity of 44%. The aorta to the trachea (when the margins were visualized) had the best cut-off of 1.12 cm with a sensitivity of 81% and specificity of 69%.

Variable left ventricular hypertrophy and occasional increased aortic diameter have been reported in cats with SH. No significant echocardiographic differences in left ventricular thickness were noted between the cats with normal blood pressure and cats with SH in this study. Left ventricular hypertrophy occurs as a late remodeling change in people with SH. Waiting for echocardiographic evidence of left ventricular hypertrophy has limited clinical application for preventing progressive TOD. Aortic root dilatation, including asymmetric aortic sinuses, is recognized as TOD due to SH in human medicine. Aortic dilatation precedes aortic aneurysm formation in people. In veterinary medicine, only aortic aneurysm has been included as TOD and likely underestimates the cardiovascular risk to our veterinary patients once aortic dilatation begins.

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remodeling in dogs with confirmed systemic hypertension. Vet Radiol Ultrasound. 2022;1–10.

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Walk This Way: understanding myelopathies and when to refer

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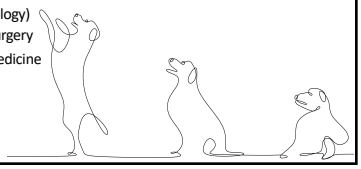
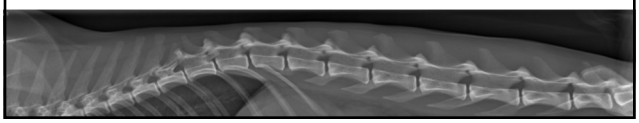


Outline

Review of common disease presentations…conservative management vs referral

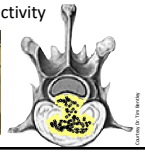
- IVDD
- FCE(M)/ANNPE/HNPE
- Inflammatory/Infectious (including Discospondylitis)
- Trauma
- Neoplasia
- Degenerative Myelopathy



Intervertebral Disc Disease (IVDD)

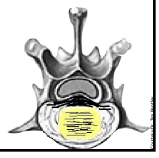
Hansen's Type I

- Acute extrusion of nuclear material into canal
- Young, chondrodystrophic breeds
- Can be secondary to traumatic events or normal activity



Hansen's Type II

- Protrusion of annulus into canal
- Large breed dogs (GSD, Labs)
- Progressive over weeks, months, years; can be acute on chronic



Intervertebral Disc Disease (IVDD)

- Most common spinal disease of dogs
- Clinical signs
  - Ambulatory is ≥ 10 unassisted steps

Modified Frankel Scale (MFS) Score	
5	Normal gait with spinal hyperesthesia
4	Ambulatory paresis
3	Non-ambulatory paresis
2	Paralysis with intact superficial pain
1	Paralysis with intact deep pain
0	Paralysis with absent deep pain ☹

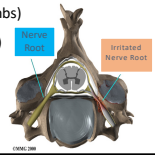
- Depends on region of spinal cord affected…
  - Upper Motor Neuron (UMN) – normal to increased tone/reflexes; long strides
  - Lower Motor Neuron (LMN) – decreased to absent tone/reflexes; short/choppy gait

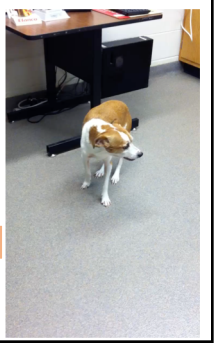
	C1-C5	C6-T2	T3-L3	L4-S3
Thoracic Limbs	UMN	LMN	Normal	Normal
Pelvic Limbs	UMN	UMN	UMN	LMN

↳ "Two engine gait" (video to explain later)

Nerve Root Signature (Radiculopathy)

- Clinical signs:
  - Holding up the limb or scuffing/knuckling the limb
  - Pain – neck or with moving limb
- Lesion localization:
  - C6-T2 myelopathy (Thoracic limbs)
  - L4-S3 myelopathy (Pelvic limbs)

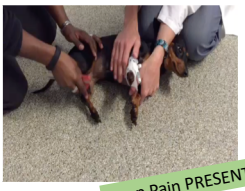




If a patient has voluntary motor, you DO NOT need to check for pain perception!

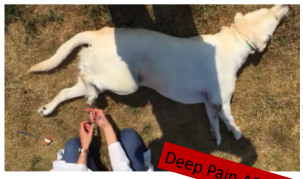
Can You See the Difference?

Normal Withdrawal Reflex



Deep Pain PRESENT

Normal Withdrawal Reflex



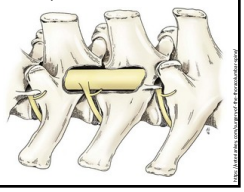
Deep Pain ABSENT

Intervertebral Disc Disease (IVDD)

- Conservative Management:
  - If only painful OR still ambulatory may do well
  - ***CRATE REST* x 2 weeks** → recheck → if improved continue x 4-6 weeks → then gradual return to activity over 8 weeks → **lifestyle changes indefinitely**
  - Multimodal Pain Medications:
    - Gabapentin 10 mg/kg PO q8-12hrs
    - +/- Codeine 1-2 mg/kg PO q8-12hrs
    - If cervical muscle fasciculations: Methocarbamol 20 mg/kg PO q8hrs
    - If wound-up pain: Amantadine 2-5 mg/kg PO q24hrs
  - Steroids vs NSAIDs?
  - Plant the seed and expectation if referral…here $5000-7000 pending no complications
    - if declining or not improving…need to move forward as soon as reasonably possible

Intervertebral Disc Disease (IVDD)

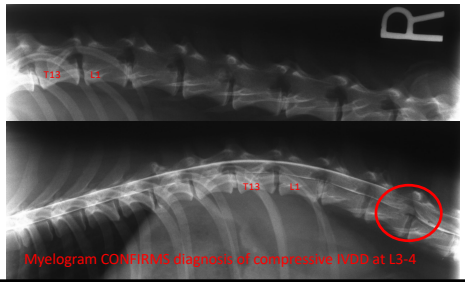
- Surgery should be pursued if non-ambulatory tetra/paraparetic →
  OR fails medical management
- Client considerations may prevent this intervention :/
- Deep pain = Prognosis
- If +, 80-90% functional recovery
  (can walk on their own and urinate on own)
- If absent, at best 50%! – needs surgery
  as soon as reasonably possible



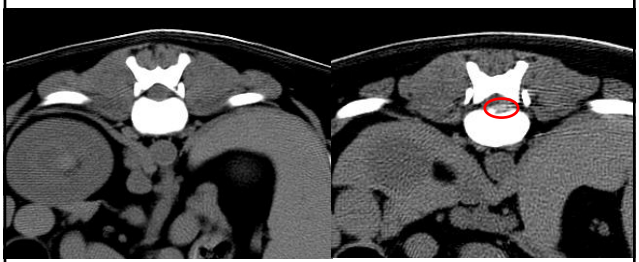
Myelomalacia (Ascending +/- Descending)

- In ≤ 10% Deep Pain Negative Dogs – up to 30% in Frenchies :/
- Flaccid paralysis in pelvic limbs; absent abdominal tone
- Absent anal tone/flaccid bladder tone
- Ascending panniculus cut off > T10
- Respiratory distress
- Refractory pain!

IVDD on Myelogram



IVDD on CT Scan



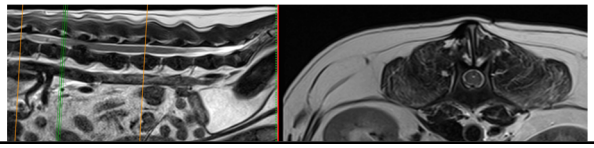
Normal thoracic spinal canal

Thoracic spine Type I IVDD

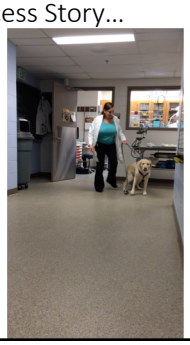
Meet "Hank"…

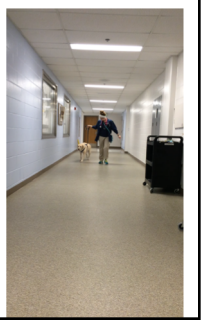
The severity of clinical signs does NOT always correlate with the degree of compression…

Meet Hank's Disc…



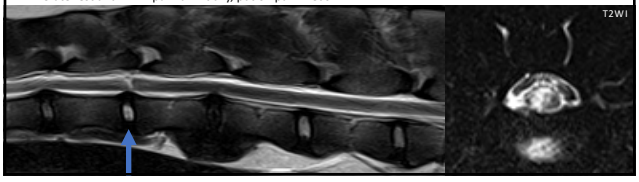
Another IVDD Success Story…





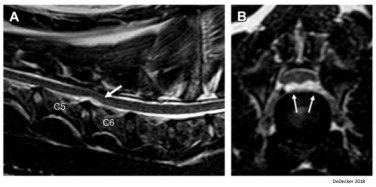
Acute Non-Compressive Nucleus Pulposus Extrusion (ANNPE)

- **Normal, hydrated disc material is acutely extruded**
- Can be secondary to traumatic event
- +/- hyperesthesia
- **Concussive injury to spinal cord; not compressive**
- T2 hyperintensity in cord from high velocity of material hitting cord, but not causing compression
- Crate rest and PT…if painful initially, put on pain meds



Hydrated Nucleus Pulposus Extrusion (HNPE)

- Extrusion of hydrated disc material **causing compression**
- Predilection for **cervica**l spine
- Acute onset nonambulatory tetraparesis/plegia
- +/- hyperesthesia
- MRI – T2 hyperintense compressive material with ”seagull” appearance and narrowed disc space
- Conservative vs surgical intervention controversial



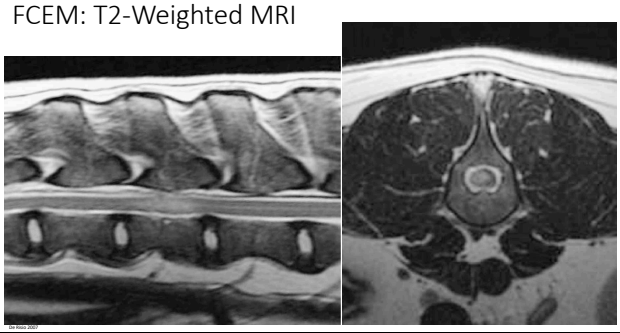
DeDecker 2018

Fibrocartilaginous Embolic Myelopathy (FCE(M))

- “Stroke” – Embolization of artery/vein (gray > white matter affected)
- Material thought to originate from IVD
- Large/giant breeds; 20% less than 20 kgs
  - Mini schnauzer, Shelties
- Young to middle-aged dogs; cats median 10 years
- Asymmetric; non-progressive ≥24 hours
- NON-PAINFUL
- Dogs L4-S3 > T3-L3; Cats C6-T2
- Length expressed as ratio over C6 or L2 and cross-sectional area (%)
  - Length ratio < 2 or < 67% cross sectional area were significantly more likely to recover
- Median time to max recovery 3.75 months

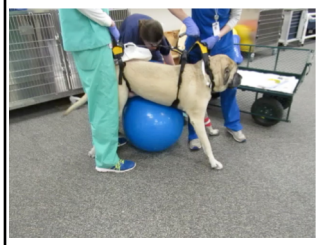
https://www.vbs.org/conservative-management-of-fibrocartilaginous-embolic-myelopathy-in-dogs-and-cats/

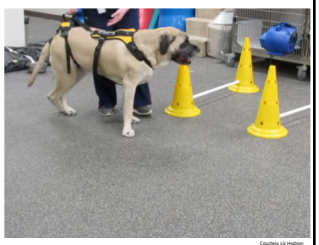
FCEM: T2-Weighted MRI



De Risio 2007

Fibrocartilaginous embolic myelopathy (FCEM)





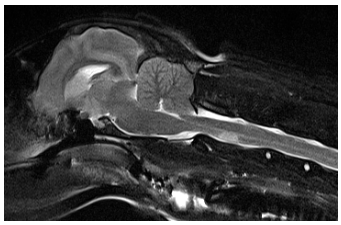
Courtesy Liz Hodson

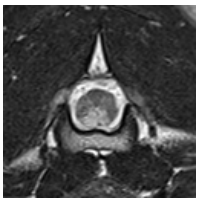
Meet "Zeni"

Courtesy Dr. Stephanie Thomasseby

- 17 year old FS DSH
- 1 day history of non-ambulatory tetraparesis
- 1.5 month history of bilateral visual deficits due to systemic hypertension… on Amlodipine
- Grade III/VI systolic heart murmur
- Fundic exam = punctate hemorrhages OU
- Exam: non-ambulatory tetraparesis with increased extensor tone (TLs > PLs)
- Localized C1-C5 myelopathy

Cat with vascular lesion… Feline Ischemic Myelopathy





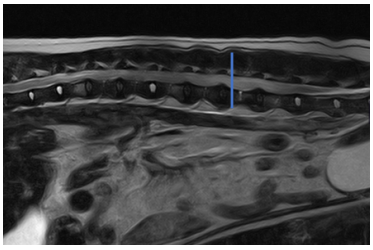
Well demarcated elliptical T2 hyperintensity common at C2-C3; vascular territory of ventral spinal artery

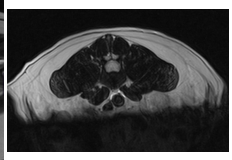
****Seen with concurrent systemic disease (hypertension, hyperthyroid, chronic kidney disease, hypertrophic cardiomyopathy) as opposed to an FCEM where there would be no other systemic disease (Relapse possible!)****

Inflammatory – Meningo(encephalo)myelitis of Unknown Etiology (MUE)

- Multifocal CNS inflammatory disease
- Acute onset, progressive
- Young to middle-aged toy/small breed dogs
- r/o infectious: toxoplasma, neospora, RMSF, Ehrlichia, cryptococcus; fungal organisms if appropriate!
- Treatment: mainstay = immunosuppressive Prednisone (2 mg/kg/day) tapering by 25% every 4-8 weeks to lowest effective dose over time
  - Depending response +/- additional immunosuppressive (Cytosar®, Cyclosporine, Mycophenolate, Leflunomide)

Inflammatory – Meningo(encephalo)myelitis of Unknown Etiology (MUE)



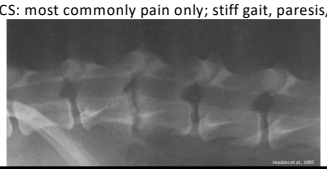


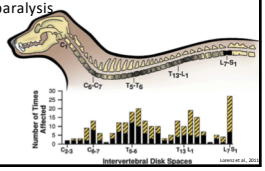
Inflammatory – Steroid Responsive Meningitis Arteritis (SRMA)

- aka "Beagle Pain Syndrome"
- Immune vasculitis of meningeal a. and meningitis
- Sometimes infiltrates CNS parenchyma
- 6 months to 2 year old large breed dogs and Beagles
- CS: severe neck pain, +/- cervical myelopathy, +/- febrile; rarely can cause seizures
- Diagnosed with MRI and CSF tap (neutrophilic pleocytosis)
- Can present with concurrent polyarthropathy
- Treatment: Once infectious titers confirm negative → increase to immunosuppressive steroids (Prednisone 2 mg/kg/day tapering by 25% every 4-8 weeks pending clinical response weaning to lowest effective dose

Infectious Spinal Cord Disease - Discospondylitis

- Infection of disc and adjacent vertebral bodies
- Hematogenous spread or direct infection (surgery, penetrating wound, migrating awn)
- *Staphylococcus intermedius/aureus*, *Streptococcus*, *Escherichia coli*, ***Brucella canis;*** fungal testing (*Aspergillus* – German Shepherds)
  - ***Test all for Brucella as Zoonotic!***
- CS: most commonly pain only; stiff gait, paresis/paralysis

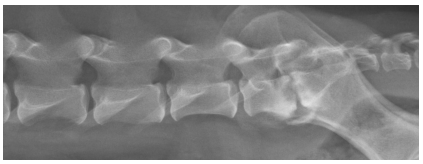




Discospondylitis - Diagnostics

- Urine culture: positive in about 25-50%
- Blood cultures: 3 samples 1 hour apart vs 3 sites all at once; positive in about 45-75%
- Tube agglutination for *B. Canis*
- +/- echocardiogram – if new murmur or febrile r/o endocarditis
- Radiographic abnormalities lag behind onset of clinical signs for average of 2-3 weeks (Shamir et al., 2001)

When to refer…
if worsening or NOT improving after 2 weeks



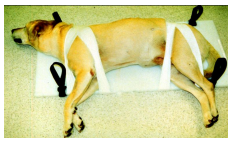
Antibiotics for Discospondylitis

Organism	Antibiotic	Dosage
Staphylococcus spp	**Cephalexin**	**20-30 mg/kg PO TID**
	Cefazolin	20 mg/kg IV, IM, SQ QID
	Cloxacillin	10 mg/kg IV, IM, PO QID
	Oxacillin	15-25 mg/kg PO T-QID
	Amoxicillin-clavulanate	12.5-25 mg/kg PO B-TID
Streptococcus spp	Amoxicillin	20 mg/kg PO BID
Brucella canis	Enrofloxacin	10-20 mg/kg PO SID
	Doxycycline	25 mg/kg PO BID
Actinomyces spp	Penicillin G	100,000 U/kg IV, IM, SC, QID
Aspergillus spp	Ketoconazole	10 mg/kg PO BID (dog); 50 mg/kg PO BID (cat)
	Fluconazole	5 mg/kg PO BID (dog); 50 mg/kg PO BID (cat)
Escherichia coli	Enrofloxacin	10-20 mg/kg PO SID
	Cefazolin	20 mg/kg IV, IM, SQ QID
	Cephalexin	20-30 mg/kg PO TID
	Amoxicillin-clavulanate	12.5-25 mg/kg PO B-TID
	Chloramphenicol	22 mg/kg PO, IV, SQ TID

Antibiotics for a min of 2-3 months; may need tx for 6 months - 1 year

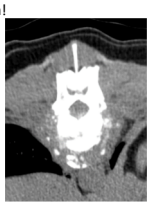
Trauma – spinal luxations/fractures

- Be cautious of patient manipulation – may need spinal board
- First steps…
  - Airway
  - Breathing
  - Circulation
- Assess patient
  - TPR
  - Physical exam – though may be limited
- Identify and treat life-threatening conditions first



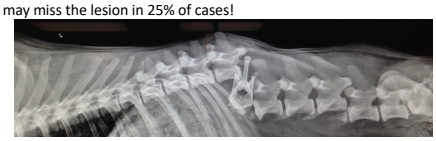
Trauma – spinal luxations/fractures

- Orthopedic Examination
- Neurological Examination
  - Be as complete as possible but be careful with manipulation!
    - Mentation
    - Cranial nerve exam
    - Posture assessment
    - Motor function
    - Reflexes
  - If paralyzed…
    - Withdrawal reflex DOES NOT MEAN PATIENT FEELS STIMULUS
    - Deep pain perception assessment
      - If deep pain intact, prognosis is fair to good (medical vs surgery)
      - If deep pain negative = poor prognosis (for functional recovery)



Trauma – spinal luxations/fractures

- Once patient is stable…
- Diagnostics
  - Survey radiographs (orthogonal views!)
    - Minimize spinal movement – horizontal beam?
    - Radiograph the entire spine – they can have multiple lesions (20%)!
    - Radiographs may miss the lesion in 25% of cases!
  - CT scan +/- MRI



Trauma – spinal luxations/fractures

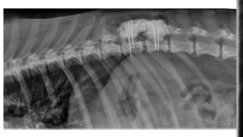
Conservative Management

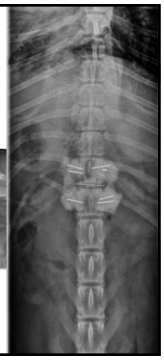
- STRICT cage rest for 8-12 weeks
- +/- external splinting
  - Cotton padding
  - Gauze cling wrap
  - Vet wrap
- Pain control
- Bladder management*
- Recumbent care*

Trauma – spinal luxations/fractures

Surgical stabilization performed when…

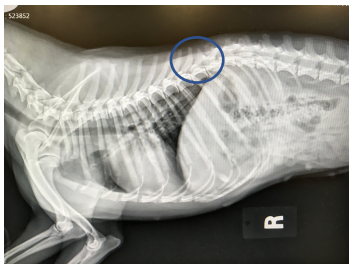
- Patient has significant neuro signs
- Moderate to severe displacement of spine
- Worsening of neurological status

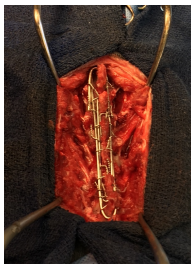




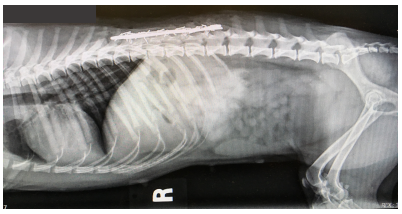
Plant the seed and expectation for referral…surgery here $7000-10,000 pending no complications. Additionally, will have post-operative recheck radiographs and may need revisional surgery over time if implant failure.

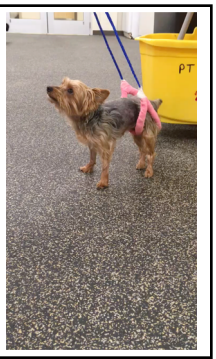
Trauma – spinal luxations/fractures





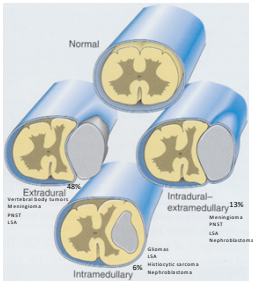
Trauma – spinal luxations/fractures





Neoplasia

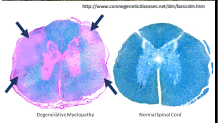
- Variety of primary vs secondary tumors
- Lymphoma most common in cats
  - Prevalence 28-40%
  - Bimodal
  - Extra-CNS disease in 85%
- Meningiomas – cranial cervical region (dogs)
- Peripheral Nerve Sheath Tumor (PNST) –
  - Nerve root signature; muscle atrophy; axillary mass/pain; can invade spinal cord
- Nephroblastoma – young dogs :/



Degenerative Myelopathy (DM)

http://www.caninegeneticdiseases.net/dm/basicdm.htm

- Progressive, non-painful T3-L3 myelopathy
- Medium to large breed dogs > 5 years (mean 9 years)
- German shepherds, Boxers, Corgis
- MRI/CT scan unremarkable
- Axon and myelin degeneration in dorsal aspect of lateral funiculi and dorsal funiculi
- Superoxide dismutase 1 (SOD1) gene mutation → genetic testing



Degenerative Myelopathy Normal Spinal Cord

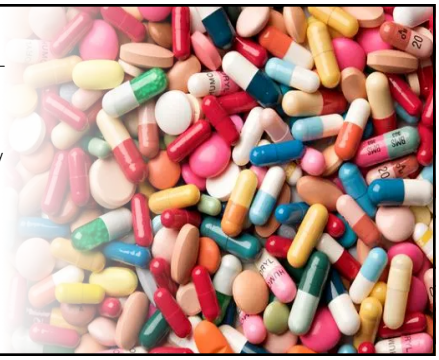
Canine Genetic Diseases Network
University of Missouri
https://cgd.missouri.edu/

Degenerative Myelopathy (DM) – Treatments?

Courtesy Liz Hodson

- Physical therapy – intensive daily therapy = walking, passive range of motion, massage of the limbs and **hydrotherapy** significantly improved mean survival time (255 days) > moderate physiotherapy (130 days) or no physiotherapy (55 days) - Kathmann et al., 2006

Degenerative Myelopathy (DM) – Treatments?



- Medications?
  - Lack of confirmed efficacy
  - Aminocaproic acid
  - N-acetylcysteine
  - Vitamin E
  - Vitamin C
  - Riluzole
  - Steroid trial
- Most are euthanized within 6-12 months of diagnosis :/

Not to forget cats…

- Cats rarely have IVDD!!!
- Consider Inflammatory/infectious (toxoplasma, FIP, cryptococcus)
- Neoplasia (LSA vs other)
- Vascular (FCEM/Ischemic myelopathy)

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Suffering Not Allowed: Treatment Options for Chronic Pain

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Abstract: Chronic pain can be very difficult to treat, but treatment is imperative for the patient's health, behavior and quality of life. A variety of pharmacologic and non-pharmacologic treatments for chronic pain, including the new anti-nerve growth factor monoclonal antibodies, are available.

Key Words: pain, chronic, maladaptive, neuropathic, drugs, nonpharmacologic

Pain causes a myriad of adverse health effects mediated by the sympathoadrenal and neuroendocrine systems. Pain causes welfare concerns and impaired quality of life, like anorexia and insomnia, and behavior changes like fear/anxiety/stress and even aggression. Behavior changes can negatively impact the human-animal bond, which is a travesty for both the human and the pet and may cause loss of the client from the veterinary clinic. In addition, neuroplasticity (peripheral and central sensitization) leading to a continual worsening of pain is likely with un- or under-treated pain. Acute pain is largely protective and a normal survival process that 'protects' from injury or ongoing tissue damage. Acute pain is also called 'physiologic' or 'adaptive'. However, the neuroplastic changes from un- or undertreated acute pain can result in chronic pain. Because of pathophysiologic changes in the central nervous system, chronic pain can continue long after tissue healing. Since there is no longer healing tissue to 'protect', chronic pain serves '**no biological purpose**' and is called '**pathologic**' or '**maladaptive**' pain. Chronic pain can be difficult to treat and poorly responsive to conventional analgesic therapy. Chronic pain should be considered a terminal disease as inability to control pain is a major contributor to euthanasia.

Causes of chronic pain: As is the case in human medicine, osteoarthritis (OA) or degenerative joint disease (DJD) is the main cause of chronic pain in dogs and cats. Cancer is the second leading cause. As mentioned, un- or undertreated acute pain can also lead to chronic pain. Based on the population of aged dogs, it is estimated that 2 in 5 (40%) adult dogs are likely to have some form of OA. Based on radiographic evidence, 40% of the general cat population (Godfrey 2005) and 90% of cats over 12 years old (Hardie EM, et al. 2002) may have OA. In dogs, large-breed, high activity level, age > 7 years, previous joint injury or surgery and obesity are all risk-factors for development of OA. Weight loss is an important part of therapy! Current evidence in cats only links geriatric age as a risk factor, but obesity may play a role in degree of pain. If diagnosed after the disease has become moderate to severe, the disease is more complex and multimodal therapy will likely be required and even aggressive therapy may not completely eliminate all pain. Thus, it is imperative that we promote identification of OA early in the disease process by **emphasizing the signs of OA pain to our clients and to our staff members** who

may be involved in patient physical examinations and/or pain-related discussions with pet owners.

Analgesic drugs: According to the new AAHA Pain Management Guidelines for dogs and cats (Gruen et al. J Am Anim Hosp Assoc 2022 Mar 1;58(2):55-76; https://www.aaha.org/aaha-guidelines/2022-aaha-pain-management-guidelines-for-dogs-and-cats/home/), the drugs with the most predictable response rate and proven efficacy for treatment of chronic pain in dogs and cats are non-steroidal anti-inflammatory drugs (NSAIDs) and anti-nerve growth factor monoclonal antibodies (antiNGF-mAbs).

AntiNGF-mAbs: Monoclonal antibody drugs are a leading platform for drug development because they have several advantages over most traditional pharmaceuticals including, injection rather than oral route of administration; long duration of action (4+ weeks); targeted inactivation of specific proteins or cytokines with minimal (depending on the protein) adverse effects; and elimination of the drug through protein catabolism and recycling rather than hepatic and/or renal clearance. One mAb drug, Cytopoint®, is already available in veterinary medicine.

Nerve growth factor (NGF) is a potent pain generator and propagator, perhaps even more potent than prostaglandin. Nerve growth factor (NGF) binds to tropomyosin receptor kinase A (Trk-A) receptors on peripheral nerve endings, resulting in nociceptor depolarization and the potential for peripheral sensitization. NGF also binds to Trk-A receptors on pro-inflammatory cells like mast cells, resulting in the release of more inflammatory mediators, including more NGF, which contributes to the development of peripheral sensitization. In addition, the NGF-TrkA complex is transported to the cell body in the dorsal root ganglia (DRG), where it modulates or increases expression of other receptors and ion channels involved in pain production (eg, transient receptor potential vanilloid 1, acid-sensing ion channels, bradykinin receptors, voltage-gated sodium channels, voltage gated calcium channels and mechano-transducers; Enomoto et al. 2018). This causes phenotypic alterations in primary afferent fibers, which leads to increased excitability and a further contribution to peripheral sensitization. In addition, NGF/TrkA-mediated transcriptional changes occur, resulting in increased expression of pronociceptive neurotransmitters (eg, substance P, calcitonin gene-related peptide (CGRP) and brain-derived neurotrophic factor). With the increased nociceptive input to the dorsal horn neurons in the spinal cord, central sensitization is highly likely to develop. With the development of peripheral and central sensitization, pain becomes intense – perhaps even intolerable – to the patient, and more difficult for the veterinary professional to effectively treat.

The new anti-nerve growth factor monoclonal antibodies, which are species-specific for dogs (bedinvetmab, Librela®) and cats (frunevetmab, Solensia®), have proven highly efficacious with minimal adverse effects for the treatment of osteoarthritis pain. Frunevetmab is now the first FDA-approved chronic pain drug for cats in the US. For a thorough review of the anti-NGF mAb and more information on its use for OA in veterinary medicine see Enomoto et al. 2018 (OPEN ACCESS, https://bvajournals.onlinelibrary.wiley.com/doi/full/10.1136/vr.104590.

NSAIDs: Non-steroidal anti-inflammatory drugs (NSAIDs) are effective since most forms of chronic pain that have an inflammatory component. NSAIDs provide analgesia AND treat pain at its source (inflammation). Multiple NSAIDs are approved for treatment of chronic pain in dogs. Both meloxicam and robenacoxib are approved in some countries for treatment of both acute and chronic pain in cats. In addition to the data used to approve these drugs in those countries, there are guidelines and clinical reports describing safety & efficacy of NSAIDs when administered at the correct dose to cats to guide use in areas without NSAID approval. The meloxicam dose most commonly used for chronic pain in cats is 0.03-0.05 mg/kg PO SID, often with a loading dose of 0.1 mg/kg. Dosages as low as 0.01 mg/kg/SID may be effective (Gunew, et al. 2008) and perhaps even beneficial – or at least not harmful - in some cats with chronic kidney disease (Gowan, et al. 2012; Gowan, et al. 2011). Robenacoxib is approved at 1-2.4 mg/kg (which is also the dose range for acute pain) for a duration 'decided on an individual basis' (robenacoxib European product label). The author commonly uses 1 mg/kg SID, or less frequently if effective, for treatment of chronic pain in cats. A caveat to treatment at lower dosages in cats is that cats do exhibit a very high placebo effect so robust and frequent pain assessment should be a component of low-dose therapy. Grapiprant is a 'piprant', or prostaglandin receptor antagonist anti-inflammatory drug. Grapiprant specifically antagonizes the EP4 receptor of PGE2. This receptor mediates pain and inflammation associated with OA. Because prostaglandins are not blocked, those involved in homeostasis are not affected and the adverse effects commonly associated with traditional NSAIDs (eg, gastrointestinal upset & ulceration and renal & kidney damage) are decreased (Rausch-Derra LC et al 2015)). The drug may be less effective than traditional NSAIDs in some patients because of the very specific target. At the time this manuscript was written, grapiprant was not approved in cats but a published safety study showed a wide safety margin in cats (Rausch-Derra & Rhodes, 2016).

Gabapentin: Gabapentin can be effective in treating neuropathic pain, primarily as part of a multimodal protocol. Neuropathic pain is pain from nervous system pathology and includes conditions that cause direct pathology of the nervous system (eg, herniated discs, nerve root tumors), pressure on nerves (eg, osteophytes near nerves) or nerve damage (eg, trauma, surgery – especially when large nerves are cut). **In addition, neuropathic pain can be a result of the pathologic changes that occur in the pain pathway in chronic pain**. There are few published research studies on the analgesic effects of gabapentin in dogs and cats but the drug is commonly used for control of various pain syndromes. In one of the few published studies, a dose of 10 mg/kg gabapentin BID improved owner-identified impaired activities in osteoarthritic cats (Guedes et al 2018). In dogs with neuropathic pain secondary to Chiari malformation, the addition of gabapentin was more effective in improving quality of life than carprofen alone (Plessas et al 2015). The dosage generally ranges from 3-10 mg/kg PO BID to QID but dosages as high as 50 mg/kg BID have been anecdotally reported. Generally, gabapentin therapy should be initiated at **10 mg/kg PO BID-TID** and dosages/dosing frequency increased as necessary.

Starting as dosages as low as 3-5 mg/kg BID may be necessary in some patients but low doses often result in lack of efficacy (see chart below). The most common side effect is sedation and the dose of gabapentin should be reduced in patients that become sedate. Gradually increasing the dose over time generally eliminates the chance of sedation and, if sedation does occur, tolerance to sedation commonly occurs within a few days. During this time, the owner will likely need counseling on continuation of the drug. However, sedation is not necessarily an adverse effect if it allows the patient to get restful sleep. So increasing night-time dosages but not day-time dosages can be beneficial both for the pet's sleep (and subsequently sleep for the owners!) and for decreasing pet-owners concerns about sedation. Gabapentin-mediated ataxia can occur, especially in older, larger dogs with decreased muscle mass. This can make the dog seem 'worse' to the owners and, unfortunately, does not seem to resolve with time. Thus, gabapentin should likely be discontinued if ataxia occurs.

Pregabalin: The mechanism of action of pregabalin is the same as that for gabapentin but the drug undergoes linear pharmacokinetics, making dosing easier. Pregabalin is widely used in human medicine for treatment of a variety of chronic pain conditions. Research in animals is limited but has, for example, been shown to alleviate central pain from syringomyelia in Cavalier King Charles Spaniels (Thoefner et al. 2019; Sanchiz-Mora et al. 2019).

Other Anxiolytics/Antidepressants: Antidepressants are a common addition to pain management in humans. Their role in the pain pathway is in the descending inhibitory limb, which is a feed-back mechanism from central centers to the spinal cord. The tricyclic antidepressant amitriptyline at 3–4 mg/kg PO BID may be an effective component of a multimodal protocol in some patients (Moore 2016). In human medicine, serotonin and norepinephrine reuptake inhibitors (SNRIs; duloxetine, venlafaxine, desvenlafaxine, and milnacipran) are used for pain relief but no data are available for vet patients.

Tramadol: Tramadol may have some efficacy via the SNRI mechanism in dogs and cats. Cats also have an opioid effect but dogs produce little of the intermediate (M-1) opioid metabolite that is likely responsible for most of the tramadol-mediated analgesia. Tramadol used alone in dogs is unlikely to provide analgesia for OA pain (Budsberg et al 2018). Tramadol was effective at controlling osteoarthritis pain in cats (Monteiro et al 2017) but the margin between the effective dose and the dysphoric dose is very narrow. Cats really dislike the taste of tramadol.

Ketamine: Ketamine is an N-methyl-D-aspartate (NMDA) receptor antagonist and plays a role in both anesthesia & analgesia. Activation of the NMDA receptors in the dorsal horn of the spinal cord are, in large part, responsible for the pain of central sensitization (or 'wind up). By antagonizing these receptors, the pain pathway can be returned to 'normal'. Meaning that the patient may still feel pain (thus ketamine must be part of a multimodal protocol) but that the pain is not exaggerated and is more likely to be controlled by traditional analgesic drugs like NSAIDs

and opioids. To achieve this effect, ketamine is best administered as an infusion, but subcutaneous administration may be somewhat effective. The analgesic effects of ketamine in chronic pain states have been fairly well-documented in humans (Remerand et al. 2009; Sigtermans et al. 2009; Cohen et al. 2018), although, as with any treatment of any chronic condition, a ketamine infusion does not always produce analgesia (Sen et al. 2009). This may be because the pain in those patients is not caused or augmented by central sensitization. In veterinary medicine, ketamine improved postoperative analgesia after forelimb amputation for up to 3 days (Wagner et al. 2002). There are no publications to guide ketamine infusions in dogs and cats for chronic pain but an infusion of 2-10 microg/kg/min following a loading bolus of 0.2-0.5 mg/kg is a common protocol. The duration of the infusion is not known. Ideally, the infusion would be administered until the patient exhibits behavioral changes indicative of decreased pain but this is unlikely to be practical. Anecdotal reports include everything from 2 to 24 hours but the common range used for logistical efficiency (not proven for analgesia) is 4-6 hours. This may lead to ineffectiveness in some patients as growing evidence in human medicine shows the need for longer infusion times. The infusion is repeated 'as needed', which could be anything from never again to weekly. Anecdotally but with growing clinical acceptance, ketamine can be administered subcutaneously at monthly, or more often, intervals. The author's clinical experience is that this is not as likely to work as an infusion so severe pain should be treated with an infusion if possible. However, SQ is more cost effective and should not be ruled out. See dosing guidelines in the chart at the end of the notes and see more information at https://www.zeropainphilosophy.com/. As stated, ketamine is part of a multimodal protocol and the goal is to return quality of life to the patient but not necessarily to eliminate any other analgesic therapies. When using infusions, consider combining with lidocaine.

Amantadine: Amantadine also antagonizes the N-methyl-D-aspartate (NMDA) receptors, just like ketamine. In humans, the NMDA-receptor antagonists are being extensively researched and have been used for treatment of acute, chronic and 'specialized' (eg, neuropathic and phantom limb) pain conditions. Newer NMDA-receptor antagonists (eg, memantine) are available in human medicine. The role of amantadine in pain management has been reported in dogs by Lascelles et al (2008). Effective pain control was achieved when amantadine was combined with an NSAID and dosed at 5 mg/kg orally for 21 days. A recent literature search yielded no other veterinary publications describing the use of amantadine for analgesia. Amantadine has a variety of uses in chronic pain and should be added to the treatment protocol anytime central sensitization could be contributing to the overall pain level of the patient. Scenarios include: NSAIDs suddenly 'not working' after controlling pain long-term, long standing untreated pain, moderate to severe cancer pain and osteoarthritis. Amantadine should be dosed at 2-7 mg/kg SID-BID (**BID is recommended for most patients but start with SID in patients that may clear the drug slowly, eg, geriatrics**) for at least 3 weeks. It can be made as a compounded liquid, which may be easier to administer to cats. Amantadine is outlawed for veterinary use in

some countries because the drug also has anti-viral effects and the concern is that over-use could lead to treatment-resistant viruses.

Opioids: Opioids are not traditionally used – and are not the most effective drug class – for treatment of chronic pain but may be necessary for profound pain and for break-through pain. Opioids to consider include transdermal fentanyl and oral formulations of codeine, codeine + acetaminophen (DOGS ONLY), morphine, oxycodone, hydrocodone and methadone. These opioids are DEA scheduled (fentanyl, codeine and morphine are Class II, codeine with acetaminophen is Class III) and have a high potential to cause adverse effects (primarily sedation, nausea and, eventually, constipation). Research trials have shown that orally delivered opioids are fairly ineffective for analgesia because of their low bioavailability (KuKanich 2013) but clinical use supports their efficacy in **some** patients. Fentanyl patches can be used in times of severe break-through pain or for 'end-stage' pain when a few days of pain relief prior to euthanasia are needed. Buprenorphine (Class III) can be administered on the oral mucosa for both acute and chronic pain in cats but absorption is not as good as was once thought (Giordano, et al. 2010), so recommended dosages may be higher this route of delivery to 0.03-0.05 mg/kg BID-QID. Occasionally, very low dosages are surprisingly effective. Transdermal buprenorphine is FDA-approved for cats and could potentially be useful for break through pain
For all patients with chronic opioid use, consider that constipation may occur and increase dietary fiber.

Lidocaine infusions: In human medicine, perioperative lidocaine infusions have been shown to prevent the development of chronic pain (Bailey et al. 2018). Lidocaine infusions have also been shown to play a role in treatment of chronic pain and reduction of opioid need (Kandil et al. 2017). The dose is the low-end of the dose used for treatment of acute pain or arrhythmias. Remember that lidocaine infusions may be dangerous for cats. Many practitioners commonly combine lidocaine and ketamine when using infusions to 'break' the pain level.

Maropitant?: Although there are no studies on the use of maropitant to treat chronic pain, maropitant likely provides analgesia through antagonism of neurokinin-1 (NK-1) receptors in the pain pathway. Since maropitant can be administered orally, it is an option for owners to use at home and is anecdotally dosed at 2 mg/kg PO SID for conditions like chronic pancreatitis. Administer as long as needed.

Intra-articular:
Steroids: Perhaps systemically, but better -used as targeted pain therapy like steroid epidurals (methylprednisolone acetate [eg, DepoMedrol] 0.1 mg/kg) or joint injections (methylprednisolone acetate – 'dose' is generally by volume which is limited by joint size but should not exceed 0.1 mg/kg). ***Intra-articular Medical Devices:*** A veterinary medical device is

defined by the FDA as a product that provides function without pharmacological, chemical, or metabolic action.

Naturally derived collagen and elastin

Spryng™ is an intra-articular device that is 'indicated for use in both horses and small animals to aid in the management of lameness issues, joint pain and osteoarthritis from loss of cartilage or tissue-bone mechanical malfunction caused by joint dysfunction not associated with infection.' The product is a 'shock-absorbing matrix that works with synovial fluid to mimic the protective form and function of natural, healthy joint cartilage.' Provides up to 1-year of action. (Reference: https://www.sprynghealth.com/small-animal-how-it-works)

Radioactive Tin: Synovetin OA® is approved for intra-articular treatment of osteoarthritis elbow pain in dogs. The device uses 'novel, conversion electron therapy using Tin (117mSn)' The product 'emits low-energy electrons that cause targeted elimination of inflamed synovial cells'. Anecdotally used in joints other than the elbow. Provides up to 1-year of pain relief. (Reference: https://www.synovetin.com/how-synovetin-oar-works)

Nonpharmacologic Therapy

Nonpharmacologic treatment of OA-mediated pain includes everything from simple heat/cold therapy to more advanced techniques like physical therapy/rehabilitation and acupuncture. In addition to the modalities just listed, modalities like therapeutic ultrasound, transcutaneous electrical nerve stimulation (TENS), pulsed radio frequency, photobiomodulation, shock-wave therapy, etc. have the potential to contribute to pain relief. Evidence for efficacy of these treatments is steadily growing and other benefits include the need for administration of fewer drugs that may cause adverse effects, the support of the human-animal bond with fewer drugs for the owner to administer at home and the ability to obtain analgesic effects through mechanisms other than those obtained with pharmaceuticals. An advantage of some the simpler nonpharmacologic therapies is that owners can often be trained to utilize basic techniques at home and the pet can then benefit from more consistent therapy. Owners can be taught to utilize ice packs, heat compresses, basic exercise and physical therapy maneuvers, basic massage, and acupressure. Nonpharmacologic modalities should be considered as a viable part of pain management protocols.

List of some (not all) proposed modalities with references:

Acupuncture: Strong evidence of efficacy: Petty MC, Huntingford JL. Evidence-Based Application of Acupuncture for Pain Management in Companion Animal Medicine Vet Sci 2022 May 26;9(6):252;

Silva et al. Effect of acupuncture on pain and quality of life in canine neurological and musculoskeletal diseases. Can Vet J. 2017 Sep;58(9):941-951; Fry et al. Acupuncture for analgesia in veterinary medicine. Topics in Companion Animal Medicine 29;2014:35–42.

Physical therapy/rehabilitation: Strong evidence of efficacy of various physical therapy/rehabilitation modalities for treatment of chronic pain (Lamoreaux Hesbach A. Manual therapy in veterinary rehabilitation. Topics in Companion Animal Medicine 29;2014:20-23).

Massage: Corti L. Massage therapy for dogs and cats. Topics in Companion Animal Med 29;2014:54-57.
Photobiomodulation: Gross DM. Introduction to therapeutic lasers in a rehabilitation setting. Topics in Companion Animal Medicine 29;2014:49-53. Dompe et al. Photobiomodulation-Underlying Mechanism and Clinical Applications.Clin Med 2020;9(6):1724.
Myofascial trigger point release: Very effective when trigger points are present. Wall R. Introduction to myofascial trigger points in dogs. Topics in Companion Animal Medicine 29;2014:43-48.
Pulsed electromagnetic field therapy (PEMF): Gaynor JS, et al. Veterinary applications of pulsed electromagnetic field therapy. Res Vet Sci. 2018;119:1-8.
Shock wave: Increasing evidence. Increasing evidence. Example publication: Alvarez L. Extracorporeal Shockwave Therapy for Musculoskeletal Pathologies. Vet Clin North Am Small Anim Pract 2022;52(4):1033-1042.
Platelet rich plasma (PRP): Increasingly strong evidence. Example publication: Alves JC, Santos A, Jorge P.
Platelet-rich plasma therapy in dogs with bilateral hip osteoarthritis. BMC Vet Res. 2021;17(1):207.
Stem cells: There is moderate evidence in both humans and animals (examples: Kim et al. 2019; Sasaki et al. 2019; Shah et al. 2018) that stem cell administration can decrease pain from osteoarthritis. The limitations are cost (several thousand dollars per treatment) and need for anesthesia/sedation. There are several types of stem cells (eg, umbilical cord, mesenchymal) supplied from a variety of sources (autologous [patient's own cells], allogeneic [cells from a donor of the same species], xenographic [cells from another species, generally human umbilicus]).

'Chondroprotective' compounds
Injectable polysulfated glycosaminoglycan (PSGAG) is FDA-approved for the treatment of OA in dogs (Adequan®) in the US and pentosan polysulfate (Cartrophen) is used in Canada. The evidence for efficacy is moderate, with some patients not responding and some having a profound response. It is commonly used in cats at the same dose used in dogs. An advantage of this compound is that it can be administered IM or SQ by the owner at home, which means that some patients may be more likely to get treated since the cat doesn't have to come to the hospital. However, because any improvement that does occur is fairly slow, these compounds should be used as adjunctive therapy to NSAIDs or other rapidly-acting, more potent analgesic drugs when pain is moderate to severe.

Dietary supplements, nutraceuticals
Evidence supporting the efficacy of many compounds is fairly sparse and not always scientifically based. However, evidence for efficacy of undenatured collagen type II, omega 3

fatty acids and green lipped mussel compounds warrants use, especially the green-lipped mussel. Diets rich in these compounds can also be very effective, especially when started early in the OA process – or, better, before OA develops. These compounds may not truly provide analgesia, but improved joint health will decrease pain sources. For the nutraceuticals, studies on specific products may never occur, but studies on the active ingredients already exist for many of the compounds. Guide the owner into choosing products with ingredients that are proven effective.

Other compounds:
Cannabinoids (CBD): The potential roles of the endocannabinoid system in pain mitigation are well-documented but research/clinical studies on specific products are lacking and product information is crucial to evidence-based-medicine treatment of pain. One study has been published (Gamble et al. 2018). A good review on the topic from human medicine is: VanDolah HJ, Bauer BA, Mauck KF. Clinicians' Guide to Cannabidiol and Hemp Oils. Mayo Clin Proc. 2019 Sep;94(9):1840-1851 (OPEN ACCESS). Currently studies are limited by legal issues and clinical use is hampered because product ingredients and purity are not regulated.

Pain Identification/Assessment: Especially with chronic pain, the owner is critical in evaluation of their pet's pain level and pain relief. The biggest hurdle to treating chronic pain is getting patients with chronic pain into the hospital for a diagnosis. Increased use of tools to identify – **and to help pet owners identify** – pain in animals should be a major drive in every practice. Unfortunately, animals rarely show pain in the veterinary clinic and owners generally have difficulty recognizing pain at home. A very important concept in owner education is the fact that we don't see pain, we see the *impact* of pain, or the 'pain affect' on the pet. This is generally recognized by changes in behavior and mobility. Once changes in these aspects are identified as pain-related, the owner should also be counseled on the impact of pain on the pet's quality of life (QOL). Since the main concern about untreated/ undertreated pain is affective changes and decreased QOL, this is not only often the easiest for the owner but also the most appropriate way to assess pain. Quality of life (QOL) scales can be very effective for pain identification by the owner.

Conclusion: Chronic pain can drastically alter a patient's health, behavior and quality of life and can, unfortunately, be difficult to treat. In order to obtain adequate pain control, multimodal therapy will likely be necessary in patients with moderate to severe pain. Unfortunately, the number of drugs and techniques that are available to treat chronic pain is fairly limited and knowledge of the use of these drugs and techniques in dogs and cats is even more limited. However, because chronic pain is a major problem in human medicine as well as veterinary medicine, research into the relief of chronic pain is extensive. Hopefully, new drugs and techniques developed for humans will continue to become available to our veterinary patients.

Dosages for drugs other than NSAIDs used to treat chronic pain in dogs and cats. Not all drugs / dosages are approved for use. PO=oral, SC=subcutaneous, IM=intramuscular, IV=intravenous, OTM=oral transmucosal. SID=once daily, BID=twice daily, TID=three times daily, QID=four times daily. Listed in alphabetical order – not necessarily by order of preference.

Drug	**DOG Dosage mg/kg unless otherwise stated**	**CAT Dosage mg/kg unless otherwise stated**	**Comments**
Amantadine (Various capsules, liquid)	2-7 PO SID-**BID** for at least 21 days	2-7 mg/kg PO SID-**BID** for at least 21 days	Does not provide analgesia directly but helps prevent / treat wind-up due to NMDA receptor antagonist activity. Use in multimodal protocol.
Amitriptyline	3-4 PO BID	3-4 mg/kg PO BID	Serotonin-reuptake inhibition may provide analgesia through the descending inhibitory limb of the pain pathway. Some proof of this in humans. Tastes bad and $$.
Anti-NGFmAb	Minimum 0.5-1.0 mg/kg	Minimum 1 mg/kg LABEL: 1 **mL** cats 2.5-7.0 kg; 2 **mL** 7.1-14 kg	SQ administration provides 4+ weeks of analgesia.
CBD oil	2 PO BID	Unknown	Gamble LJ, et al. Front Vet Sci. 2018 Jul 23;5:165.
Gabapentin (multiple tablet or capsule sizes; liquid)	3-20 PO BID-QID; up to 50; usually start with 5-10	3-20 PO BID-QID; up to 50; usually start with 5-10	Effective for treatment of neuropathic pain. Best used as part of a multimodal protocol. Increase the dose by about 25% every 5-14 days (depending on pain severity) until the patient is more comfortable or sedate. If sedate, go back to previous dose.
Ketamine (100 mg/ml) infusion	5-15 microg/kg/ min for minimum of several hours. Optimal duration unknown.	5-15 microg/kg/ min for minimum of several hours. Optimal duration unknown.	Can be used to 'break' the cycle of severe pain. Does not provide analgesia directly but helps prevent / treat wind-up due to NMDA receptor antagonist. Use in multimodal protocol.
Ketamine (100 mg/ml) SC	0.5 mg/kg	0.5 mg/kg	At least weekly to start. Up to every day or every other day for severe pain, monthly may provide maintenance analgesia.
Lidocaine infusion	25-50 microg/kg/min	CONTROVERSIAL 10-25micg/kg/min	Combine with ketamine. Optimal infusion duration unknown.
Maropitant	1-2 PO SID	1-2 PO SID	Perhaps best for visceral pain?
Pentosan polysulfate (eg, Cartrophen [CA])	Use label dose	Use dog dose	Not scheduled for cats. Clinically most effective for mild pain or as part of a multimodal protocol.

Polysulfated Glycosamino-glycan (eg, Adequan)	4 IM twice a week for up to 4 weeks, max 8 injections (label dose)	4 IM or SQ twice a week for up to 4 weeks, max 8 injections (dog dose)	Licensed by the FDA for control of OA pain in dogs (not licensed in cats). Clinically most effective for mild pain or as part of a multimodal protocol. Uptake following SQ injection proven in cats.
Pregabalin	4 PO BID	1-2 PO BID	No analgesic studies. Can cause sedation.
Tramadol (50 mg tablets)	2-5 PO BID -QID. Low bioavailability, needs frequent dosing. Up to 10 mg/kg?	2-5 mg/kg PO BID-TID. Start with 2 mg/kg BID. High bioavailability, likely to cause dysphoria.	Tramadol is an 'opioid like' drug that has other mechanisms of action. The pharmacokinetics in the dog are somewhat erratic so the drug is best used as multimodal therapy with NSAIDs or other analgesic drugs. **DEA CONTROLLED.**
Opioids			Chronic use may cause constipation. **DEA CONTROLLED. Maybe used for break-through pain.**
Oral morphine (10,15,30 mg tablets)	0.5-2 PO TID - QID (can be dosed as often as q2-4hrs)	0.25-0.5 mg/kg PO TID-QID (can dose as up to q 3-4 hrs)	Higher doses may induce sedation or dysphoria. Nausea & vomiting may also occur but tolerance to these effects generally develops within 1 week.
Sustained release oral morphine	2-5 PO BID - QID	Difficult to dose due to size of tablets (don't cut tablets)	Higher doses may induce sedation or dysphoria. Increase the frequency of administration prior to increasing dose if duration is not long enough
Codeine (15, 30, 60 mg tablets)	1-2 PO q6-8 hrs	0.1-1.0 mg/kg PO 4-8 hrs	Higher doses may induce sedation or dysphoria. Nausea & vomiting may also occur but a tolerance to these effects generally develops within 1 week.
Codeine30-60 mg + acetaminophen (300 mg)	1-2 (codeine) PO q 8-12 hr	**TOXIC TO CATS - DO NOT USE**	Multimodal therapy improves analgesia over either drug used alone. DO NOT EXCEED 10-15 mg/kg acetaminophen per dose.
Transdermal fentanyl	3-5 ug/kg/hr	3-5 ug/kg/hr	May induce sedation or dysphoria. Adding NSAID may improve analgesia.
Methadone (various)	0.6 q 4-8 hrs OTM	0.6 mg/kg q4-8 hrs OTM	Absorbed transmucosally in cats – not yet proven in dogs but used anecdotally.
Buprenorphine (0.3mg/ml)	0.01-0.03 SC, IM, IV; 0.03-0.05 OTM	0.01-0.03 SC, IM, IV; 0.03-0.05 OTM	May cause mild opioid side effects.

FULL REFERENCES AVAILABLE FROM THE AUTHOR ON REQUEST or at VetAACE.com under Come Learn With Me/Handouts.

What's New in Anesthesia and Analgesia: New Products, Techniques and Other Stuff

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President, International Veterinary Academy of Pain Management

NOTE: Other 'new' things may be presented in lecture that are not in the notes.

Abstract: New or new uses of anesthesia and analgesia drugs, techniques and equipment may be just what you need to elevate anesthesia and analgesia to the next level in your practice.

Keywords: anesthesia, analgesia, drug, equipment, monoclonal antibody, medetomidine + vatinoxin

New Pain Management Guidelines
2022 AAHA Pain Management Guidelines for Dogs and Cats (Gruen et al. 2022) open access at AAHA.org/Guidelines/
https://www.aaha.org/globalassets/02-guidelines/2022-pain-management/resources/2022-aaha-pain-management-guidelines-for-dog-and-cats_updated_041822.pdf

World Small Animal Veterinary Association (WSAVA)Pain Management Guidelines (Monteiro et al. 2022) open access at https://wsava.org/global-guidelines/global-pain-council-guidelines/.

2022 ISFM Consensus Guidelines on the Management of Acute Pain in Cats (Steagall PV et al.) open access at https://journals.sagepub.com/doi/pdf/10.1177/1098612X211066268

All three guidelines include not only pain management information but also descriptions of the newest *pain management scoring systems/scales*, including the Feline Grimace Scale.

New (or new-ish) FDA-approved Analgesic Drugs
Anti-nerve growth factor monoclonal antibodies (anti-NGFmAbs, Solensia® and Librela®)
Nerve growth factor is a potent pain generator and propagator, perhaps even more potent than prostaglandins. Monoclonal antibody drugs have several advantages over traditional pharmaceuticals, including injection rather than oral administration, long duration of action (4+ weeks) and elimination through protein catabolism and recycling rather than hepatic and/or renal clearance. The anti-NGFmAbs are species-specific for treatment of osteoarthritis pain in dogs (bedinvetmab, Librela®) and cats (frunevetmab, Solensia®) with minimal adverse effects. Both drugs are approved for their respective species in numerous countries, including the US.

Extended duration transdermal buprenorphine solution for cats (Zorbium®)
Buprenorphine is a moderately potent opioid with a high safety profile and a duration of action of 4-6 hours for surgical pain, with presumed slightly longer duration for mild pain. A high-concentration injectable formulation (Simbadol™) that provides analgesia for 24-hours is currently on the market. A new addition is a transdermal buprenorphine (Zorbium™) that provides analgesia for 4 days. Both are FDA-approved for cats only. Adverse effects are typical of opioids and include mild hyperthermia. Although both are approved for pre-surgical use, both can also be used for post-operative use. A common protocol is to use a more potent opioid as a premedication and follow with the longer duration opioid postoperatively. The timing of administration for the long-duration buprenorphine administration should be within 1-2 hours before the analgesic effects of the first opioid are predicted to wear off since both extended duration products take 1-2 hours for full effect. An advantage of the transdermal formulation is post-discharge analgesia without the need for the owner to administer the drug.

Simbadol® (long-duration buprenorphine)
Buprenorphine with 24-hour duration FDA-approved for use in cats for preoperative administration but the slow onset makes postoperative administration more practical in many instances. The label dose may cause sedation in patients that are receiving other analgesic drugs and in ill or old patients that are slow to metabolize the drug. We commonly use 75% of the label dose in patients that would receive low-end dosages of any other opioid that we use. Can be used off-label in dogs just like 'regular' buprenorphine at 0.02 mg/kg IV or IM – but poor uptake if used SQ at this dose. Simbadol administered to dogs at a dose of 0.02 mg/kg IM PLUS carprofen provided pain and sedation scores not significantly different from those proved by the same dose of 'regular' buprenorphine for 6 hours postoperatively (not tested beyond that time frame) – but 3 dogs in the regular group and 0 dogs in the Simbadol group required rescue analgesia postoperatively (Watanabe et al. 2018). Uptake at this route/dose is REALLY low after SQ administration but good IV or IM.

Liposome Encapsulated Bupivacaine (*Nocita®)*
Not completely new but new information on storage. The liposome encapsulated bupivacaine Nocita® is approved for incisional injection for stifle surgery in dogs and peripheral nerve block for manus desensitization in cats. However, the drug is widely used off-label for other incisional, wound and peripheral nerve blocks. Liposome encapsulation increases the duration (72 hours) and safety as small amounts of bupivacaine are slowly released. Research shows that the liposomes maintained integrity and there was no bacterial or viral contamination for 4 days after Nocita® vials were **aseptically** punctured (Carlson et al, 2020). Using the drug for a longer time will allow easier division of the drug (and the costs) among patients. If the surgery includes an implant that could get infected, opening a new vial is recommended.

New Medical 'Devices' for Joint Injections

A veterinary medical device is defined by the FDA as a product that provides function without pharmacological, chemical, or metabolic action.

Naturally derived collagen and elastin

Spryng™ is an intra-articular device that is 'indicated for use in both horses and small animals to aid in the management of lameness issues, joint pain and osteoarthritis from loss of cartilage or tissue-bone mechanical malfunction caused by joint dysfunction not associated with infection.' The product is a 'shock-absorbing matrix that works with synovial fluid to mimic the protective form and function of natural, healthy joint cartilage.' Provides up to 1-year of action. (Reference: https://www.sprynghealth.com/small-animal-how-it-works)

Radioactive Tin

Synovetin OA® is approved for intra-articular treatment of osteoarthritis elbow pain in dogs. The device uses 'novel, conversion electron therapy using Tin (117mSn)' The product 'emits low-energy electrons that cause targeted elimination of inflamed synovial cells'. Used off-label in joints other than the elbow. Provides up to 1-year of pain relief. (Reference: https://www.synovetin.com/how-synovetin-oar-works)

Other New/New(ish) Drugs

Ketamine infusions and subcutaneous injections

Ketamine is an N-methyl-D-aspartate (NMDA) receptor antagonist and plays a role in both anesthesia & analgesia. Activation of the NMDA receptors in the dorsal horn of the spinal cord are, in large part, responsible for the pain of central sensitization (or 'wind up'). By antagonizing these receptors, the pain pathway can be returned to 'normal'. Meaning that the patient may still feel pain (thus ketamine must be part of a multimodal protocol) but that the pain is not exaggerated and is more likely to be controlled by traditional analgesic drugs like NSAIDs and opioids. To best achieve this effect, ketamine should be administered as an infusion. The analgesic effects in chronic pain patients have been well-documented in humans (Remerand et al. 2009; Sigtermans et al. 2009; Cohen et al. 2018), although, as with any treatment of any chronic condition, a ketamine infusion does not always produce analgesia (Sen et al. 2009). This may be because the pain in those patients is not caused or augmented by central sensitization. In veterinary medicine, ketamine improved postoperative analgesia after forelimb amputation for up to 3 days (Wagner et al. 2002). There are no publications to guide ketamine infusions in dogs and cats for chronic pain but an infusion of 5-15 microg/kg/min following a loading bolus of 0.2-**0.5 mg/kg** (preferred) is a common protocol. The duration of the infusion is not known. Ideally, the infusion would be administered until the patient demonstrates decreased pain but this is unlikely to be practical. Anecdotal reports include everything from 2 to 24 hours but the common range is 2-6 hours. The infusion is repeated 'as needed', which could be anything from never to weekly – or even every 2-3 days for severe pain. As stated, this is part of a multimodal protocol

and the goal is to return quality of life to the patient but not necessarily to eliminate other analgesic therapies.
Anecdotally, ketamine administered at **0.5 mg/kg subcutaneously** at monthly intervals may control pain. However, this may be a 'maintenance' protocol once pain is controlled. Initial dosing used by the author is weekly, or if pain is severe, every 2-3 days, until pain relief is noted. Then the dosing interval is slowly extended and once monthly can be achieved. The pain relief is not as rapid or likely as profound as that achieved with the infusion but is more practical to administer. As with humans, neither route of ketamine administration will decrease pain in all patients. The only predictable, profound pain-relieving drugs are the NSAIDs and the antiNGF-mAbs.

QUICK CALCULATION Ketamine CRI: Add 60 mg (0.6 mls of 100 mg/ml) ketamine to a 1-L bag and run at 2 mls/kg/hr to provide 2 microg/kg/min or at surgical fluid rate (10 ml/kg/hr) to provide 10 microg/kg/min (intra-op dose). Or deliver the ketamine using a

Pregabalin
The mechanism of action of pregabalin is the same as that for gabapentin but the drug undergoes linear pharmacokinetics, making dosing easier. Pregabalin is widely used in human medicine for treatment of a variety of chronic pain conditions. Research in animals is limited but has, for example, been shown to alleviate central pain from syringomyelia in Cavalier King Charles Spaniels (Thoefner et al. 2019 & 2020; Sanchiz-Mora et al. 2019). Pharmacokinetic studies suggest dosages of 1-2 mg/kg BID in cats (Esteban MA, et al. Front Vet Sci 20;5:136, 2018) and 4 mg/kg BID in dogs (Salazar V, et al. Vet Anaesth Analg 36(6):574-80, 2009). Pregabalin may also be a better anxiolytic than gabapentin and there is an approved pregabalin anti-anxiety product for cats (Bonqat) approved in Europe/UK.

Local Blocks
Local blocks aren't new, but some techniques may be new to your practice. Here are two of my favorites:
Peritoneal lavage for ovariohysterectomy and other abdominal surgeries

1. Desensitize the incision site by injecting local anesthetics into the tissues. Incise the skin and linea.
2. Inject (or 'instill' or 'squirt') a standard dose of local anesthetic drug into the abdomen through the incision using a sterile syringe (no needle). Standard drugs/dosages: Lidocaine 2-4 mg/kg cat; 4-6 mg/kg dog; bupivacaine or ropivacaine 1-2 mg/kg cat; 2 mg/kg dog. Upper end of dosing range is recommended. If necessary, dilute local anesthetic with sterile saline to achieve a total volume of 0.4-0.6 ml/kg.

3. The drug can be injected immediately after the abdominal wall is incised (more effective) or immediately prior to closing the abdominal incision (maybe more practical since the drug isn't absorbed by sponges used to control bleeding).
4. At completion of the OHE, close the incision per routine surgical protocol, leaving the drug in the abdomen.
5. In human medicine, intraperitoneal lavage is used not only for hysterectomies but also to decrease intraoperative nociception and postoperative pain from other abdominal surgeries, including caesarean section. Intraperitoneal lavage is commonly used for these surgeries in veterinary medicine. Although no research is yet published for any surgeries other than ovariohysterectomies, experts commented that 'it is our consensus that these techniques [incisional and intraperitoneal local anesthetic administration] should be used for any type of abdominal surgery'. (Open Access: Steagall PVM, Benito J, Monteiro B, Lascelles D, Kronen PW, Murrell JC, Robertson S, Wright B, Yamashita K. Intraperitoneal and incisional analgesia in small animals: simple, cost-effective techniques. 2020;1(1):19-23.)


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CAPSULE REVIEW | Free Access

Intraperitoneal and incisional analgesia in small animals: simple, cost-effective techniques

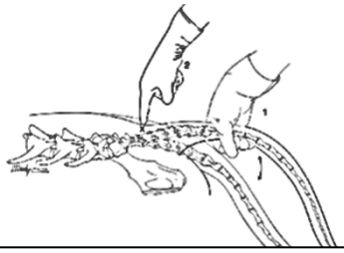
P. V. M. Steagall, J. Benito, B. Monteiro, D. Lascelles, P. W. Kronen, J. C. Murrell, S. Robertson, B. Wright, K. Yamashita

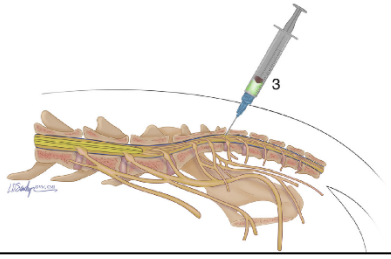
First published: 18 November 2019 | https://doi.org/10.1111/jsap.13084

Volume 61, Issue 1
January 2020
Pages 19-23

Sacrococcygeal or intercoccygeal epidural for surgery in the perineal area

1. Move the tail up and down in a 'pumping' motion while palpating the sacrococcygeal region of the patient. The first movable space at the caudal end of the sacrum is either the sacrococcygeal or intercoccygeal space. Either site is appropriate for injection.
2. Insert a 22-G needle through the skin ON MIDLINE at a 45-degree angle to the skin surface.
3. Proceed slowly until needle enters the space (generally hit bone and 'walk off' the bone).
4. Hanging drop technique may work. Should have no resistance on injection.
5. Use lidocaine for the most rapid onset or bupivacaine or ropivacaine for longer duration.
6. Dose is 0.1-0.2 ml/kg of any of the drugs. Note **mls** not mgs.
7. Opioids can be added (same as for lumbosacral epidural) to extend the duration of the analgesia but won't achieve the 24-hour duration of morphine injected into the lumbosacral space. Don't inject air, air bubble may cause incomplete block since this is a very small space.
8. This block is often used to provide analgesia for placement of urinary bladder catheters for relief urethral obstructions in cats but should not be niched to only this species or only this use. The block is widely used in large animal medicine and is appropriate for both dogs and cats for any surgery/procedure in the perineal area, including urethrostomies, tail amputations, anal gland removal, deobstipation, assisted vaginal delivery of puppies or kittens, etc.





Diagrams open access download from https://www.aaha.org/aaha-guidelines/2020-aaha-anesthesia-and-monitoring-guidelines-for-dogs-and-cats/local-anesthetic-techniques/

Pain score your patients! We can't know if our patients are painful unless we look for pain. They aren't going to tell us – we have to 'ask' them if they are in pain! The newest pain scale for cats (the Feline Grimace Scale) is validated by research (Evangelista et al. 2019) and is super easy to implement. Get the open access article AND training manual from PubMed or go straight to the training manual: https://static-content.springer.com/esm/art%3A10.1038%2Fs41598-019-55693-8/MediaObjects/41598_2019_55693_MOESM1_ESM.pdf

New Anesthesia Guidelines

Download the open access **2020 AAHA Anesthesia and Monitoring Guidelines** (Grubb et al. 2020) and use the on-line resource center (see drop down menu on right of screen at the website listed below) for guidelines on local anesthetic blocks, anesthesia equipment set-up, assessment and maintenance recommendations, checklists, etc… https://www.aaha.org/aaha-guidelines/2020-aaha-anesthesia-and-monitoring-guidelines-for-dogs-and-cats/anesthesia-and-monitoring-home/

Download the open access **AAFP Feline Anesthesia Guidelines** (Robertson et al. 2018) https://journals.sagepub.com/doi/pdf/10.1177/1098612X18781391

New (or new-ish) Sedative, Anesthetic or Support Drugs

Medetomidine + Vatinoxan (Zenalpha®)

Zenalpha® is the alpha-2 agonist medetomidine combined with the peripherally-acting alpha-2 antagonist vatinoxan. With this drug the central effects of medetomidine (sedation and analgesia) are maintained while the peripheral effects (vasoconstriction, bradycardia, etc…) are prevented or at least diminished.

Propofol

Not new – but have you ever used a 'propofol sandwich'? Administration of 1.0 mg/kg propofol prior to administration of 0.25 mg/kg midazolam followed by propofol 'to effect' until intubation was possible resulted in smoother inductions (midazolam often causes excitement when used first) and lower overall propofol dosages that administering the midazolam first. (Sanchez et al. Veterinary Anaesthesia and Analgesia 2013;40(4):359–366.

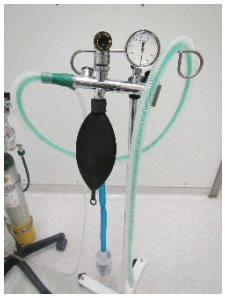
Alfaxalone (Alfaxan®)
Alfaxalone is a new-ish induction drug ('neuroactive steroid'), DEA Class IV. It can be used IV for anesthesia induction or IM for mild to moderate sedation in cats and very small dogs (otherwise the volume is too large). How to use it: 1) As an induction drug in exactly the same way that you would use propofol. Dose: 2-3 mg/kg IV in dogs, up to 5 mg/kg in cats. 2) For IM sedation in cats that may not be able to metabolize acepromazine and/or have cardiovascular disease that precludes the use of alpha-2 agonists. Administer 0.5-2 mg/kg with an opioid.

Dopamine and dobutamine (not necessarily new but new to some)
These are positive inotropic drugs used to treat hypotension by increasing myocardial contractility.
How to use them: As an infusion to improve blood pressure. It is an obvious choice in patients with cardiovascular dysfunction but should also be considered in patients who are hypotensive in spite of decreasing the inhalant dose and increasing the fluid rate. The inhalants cause hypotension by both vasodilation and decreased myocardial contractility, so even patients with healthy hearts might need to receive dopamine to improve blood pressure during general anesthesia.

Equipment
'Pop-Off' occlusion valve (or 'occlusion button')

Instead of completely closing the pop-off (or 'pressure relief') valve to give the patient a breath, just push this button for temporary closure of the valve. When you release the pressure on the button, the valve is automatically open. This prevents accidental prolonged closure of the valve – which can cause rapid pressurization of the breathing system and patient's the airway. Over-pressurization can cause cardiovascular collapse, pulmonary barotrauma, and death in a very short time (minutes).
Advantages: EASY, cheap. Will prevent an accident that can cause dire consequences.
Disadvantages: Takes two hands to give a patient a breath (small price to pay for safety); some models supposedly leak inhalant anesthetic (might be due to failure of the button to close the orifice all the way).
Source: Multiple companies, eg, Surgivet and JD Medical.

Bain 'Block' or 'Mount



Block or mount for attachment of a pressure manometer and scavenging system to the rebreathing system. This allows the pressure generated by a positive-pressure breath to be MEASURED, which decreases likelihood of barotrauma (pressure too high) or inadequate ventilation (pressure too low). Also decreases

contamination of room with waste gas because of attachment to scavenging system.
Source: Multiple companies

Syringe pumps or other volume-limiting devices
Use these for administration of drugs (analgesic CRIs, dopamine, etc…) AND for delivery of IV fluids to cats. A great way to avoid under- or over-hydration (the latter is a fairly common problem in really small patients). Over-hydration can lead to edema in a variety of tissues, most notably pulmonary edema.
Advantages: EASY to titrate drugs and fluids at an accurate dose.
Disadvantage: Some pumps are expensive; you have to learn to program them – which isn't all that hard but is something else to learn.

TIP: If you don't want syringe pumps, use buretrols (or any other fluid limiting device) when administering fluids to really small patients. OR, my favorite if equipment isn't available, just pull up the amount of fluid that the patient needs over the expected surgery duration into a syringe and have the anesthetist titrate it in a couple of mls at a time while they are monitoring the patient. Not a continuous method of delivery but close enough to continuous - and avoids overhydration. So for example, a 3 kg cat that needs 5 ml/kg/hour IV fluids that will be anesthetized for 2 hours, we draw up 3 kg x 5 ml/kg/hr x 2 hours = 30 mls of fluid into a syringe. It is easy to see 30 mls in a syringe – but really hard to determine 30 mls in a 1-liter bag of fluids.
Source: Multiple companies

Flexible foam cat mouth gags (use hair rollers!)
We don't use mouth gags for anesthesia but, of course, mouth gags are commonly used in anesthetized patients. Unfortunately, opening the mouth of a cat too wide causes decreased blood flow in the maxillary arteries (Martin-Flores et al. Vet J. 2014;200(1):60-4), which are the main blood source for the retinae and brain in the cat. The decreased blood flow secondary to mouth gag use has been implicated in post-anesthesia blindness and neurologic deficits. These deficits may resolve - but may be permanent and may result in euthanasia (Stiles et al. Vet J. 2012;193(2): 367-73).

Advantages: CHEAP! Doesn't force the mouth open excessively wide.
Disadvantages: May not open the mouth wide enough for some procedures in the caudal oral cavity. Can still open the mouth wider – but don't leave it that way too long!
TIP: Rollers can be rinsed off and re-used but just throw them away if the cat's mouth is particularly nasty or if the cat has any communicable disease. They are cheap!