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Ann Hohenhaus

GETTING THE MOST FROM A CYTOLOGY AND HISTOPATHOLOGY REPORT

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A histology or cytology report is part of a conversation between the clinician and the clinical pathologist or anatomic pathologist. This conversation has several back-and-forth points. It starts with the choice of a laboratory for sample analysis. The laboratory will provide directions for sample submission and supplies including submission forms, slide holders and formalin containers. The next step is collection of the sample with the goal of collecting a diagnostic sample. The conversation continues with submission of a request form along with the sample. The pathologist responds with the cytology or histology report. Occasionally, there is a need for the clinician to call the pathologist to discuss the results further or to request additional testing of the sample.

To get the most from a cytology report, lesion selection and sample collection greatly influence the ability to obtain a diagnostic sample. The cytology report must be interpreted in the light of the accuracy of cytology for that particular organ or anatomic location. Interpreting a histology report requires understanding the information contained in the actual report as it is critical to developing an ongoing plan for the patient.

CYTOLOGY REPORT

Sample collection - Location

Any skin mass or peripheral lymph node is an excellent lesion for cytological analysis. The results can help guide the need for antibiotic therapy, surgery, benign neglect, or cancer treatment. Fine needle aspiration of pleural effusion, peritoneal effusion or internal organs or masses is commonly performed but may require ultrasound guidance. Common internal organs undergoing fine needle aspiration include liver, spleen, kidneys, intestinal masses, enlarged lymph nodes, lung masses and mediastinal masses. Aspiration of the spleen or liver is quite easy, but interpretation can be challenging because anatomic pathologists rely on tissue architecture to make a diagnosis and this feature is lost in cytology preparations. Despite concern about adverse events, pancreatic and adrenal gland aspiration can be useful.

In about 15-20% of cytology samples, the sample is inadequate for diagnostic purposes. Firm masses and vascular lesions may not have adequate cell for interpretation. Necrotic lesions and lesions with significant inflammation are ones where cytology may not give accurate results because the secondary process can obscure the primary disorder. Low grade or well differentiated malignancies may appear benign on cytology.

Tumor staging is a clinical assessment of how large and widely disseminated a tumor is. Fine needle aspiration of lymph nodes as part of tumor staging deserves special attention. Lymph nodes do not have to be enlarged to be contain metastatic cells. Oral tumors can have lymph node metastasis on the contralateral side to the tumor. Thus aspirating multiple lymph nodes, ipsilateral and contralateral to an oral tumor is recommended even if the lymph nodes are not enlarged.

Sample collection - Technique

Multiple techniques can be used to obtain a sample for cytologic analysis. Clinical pathologists prefer samples obtained via the non-aspiration technique where a needle is used to make multiple stabs into a lesion without an attached syringe or with an attached syringe filled with air. For soft lesions, use a 23-25g needle and a 22g for firm lesions. Syringe size for non-aspiration technique is not important, but for

aspiration technique use a 3-6 cc syringe for soft lesions and 12cc for firm ones. Masses in the distal colon may be scaped using a cotton swab which can be useful to identify infectious agents such as fungi or protozoa, inflammatory cells or malignant cells. If the need for diagnosis is urgent, an impression smear of excised tissue can be made for cytological analysis while waiting for histopathology results to become available.

Adverse events
Hemorrhage from fine needle aspiration of a cutaneous mass of lymph node is uncommon, but with ultrasound guided fine needles aspirates, thrombocytopenia appears to be associated with hemorrhage. Although aspiration of adrenal gland masses and the pancreas seem risky, this belief has not been corroborated by some small studies.

Submission form
The paper or electronic submission form is the clinician's communication to the pathologist regarding location, clinical findings and differential diagnoses for the sample being submitted. This information is critical to a pathologist's ability to give an accurate interpretation of the sample that is ultimately helpful to the clinician. For example, if a mandibular lymph node is aspirated and the pathologist sees epithelial cells, they may conclude the salivary gland was aspirated. If the lymph node aspirated is not reported, the pathologist can only say epithelial cells. If the clinician has a specific question by the cytology report, it should be included on the submission form. Never submit a cytology sample in the sample transport container as a tissue sample in formalin because the quality of the cytology sample will be negatively affected.

Cytology Report
The cytology report will contain three components: a description of the sample, a diagnosis and other information like a prognosis, references or recommendations for additional testing. Examples of additional testing include a recommendation for flow cytometry or PCR for antigen receptor rearrangement in a lymph node cytology suggestive of lymphoma or for a culture and sensitivity in a sample that contains bacteria.

Clinician to Pathologist
The cytology report will contain contact information for the pathologist issuing the report. This is extremely helpful if the clinician needs to clarify the diagnosis, understand the recommended additional testing, or discuss the case further. Most pathologists welcome the opportunity to discuss cases with the submitting clinician.

Diagnostic accuracy of cytology
Aspiration cytology results for cutaneous and subcutaneous masses is quite reliable and agrees with histopathology over 90% of the time. One aspect of cytology that can limit its usefulness is the highly focal nature of the sample obtained from large organs like the spleen and liver. The architecture of the spleen and liver is important in determining the diagnosis. These two aspects cytology may explain the low rate of agreement between fine needle aspiration cytology and histopathology of the liver and the spleen. Mesenchymal tumors (sarcomas) tend not to exfoliate as well as hematopoietic tumors or epithelial tumors (carcinomas) and often several attempts must be made to obtain an adequately cellular sample from a tumor such as a soft tissue sarcoma. Samples from necrotic tumors may give a false negative diagnosis of inflammation. Overall, a diagnosis of cancer from a fine needle aspiration cytology is highly likely to be correct.

Histopathology report
Biopsy Sample Collection - Location and technique
In many cases, the location of a tumor dictates the technique used for obtaining a biopsy sample. These techniques range from simple to complex. Occasionally a piece of friable mass falls of during examination or a patient will sneeze out a piece of tissue. These samples can be placed in formalin and submitted to the laboratory. Punch biopsy is an appropriate technique for skin lesions especially if the

lesions are diffuse and not resectable. Many times, an excisional biopsy is an appropriate technique for small skin masses, but the management of skin lesions benefit from pre-operative fine needle aspiration cytology since identifying a cutaneous mast cell tumor or soft tissue sarcoma prior to surgery allows the surgeon to plan adequate surgical margins for complete removal of the tumor.

Submission form
The histopathology laboratory will provide the clinician with electronic or paper forms to submit with the sample. It is critical for the form to be completed in order for the pathologist to have adequate information to respond with an accurate histopathology report.

Histology Report
Like the cytology report, a histology report will include a description of the tissue sample, a diagnosis, prognosis and the case of some tumors, tumor grade. Tumor grade is derived from histologic features that influence prognosis. A perfect grading system would be one that clearly separates patients into good and poor outcome groups while also being reproducible when used by multiple pathologists. Two of the most commonly used grading systems in veterinary oncology are ones for canine cutaneous mast cell tumors and soft tissue sarcomas.

The report may also contain comments, references and further recommend diagnostic testing. In this section the pathologist explains unusual findings, gives references to support their conclusions and makes suggestions for additional testing. Recommendations for additional testing often include immunohistochemistry as a method to further define the tumor type. When a pathologist recommends immunohistochemistry to further characterize a tumor, this testing should be performed if the pet owner desires further clarification of prognosis or the information gained from immunohistochemistry will alter treatment recommendations. Additional stains may also be recommended if the appearance of the tissue suggests and infectious etiology such as fungi or mycobacteria.

When a pathologist includes a reference in the histology report, they provide the clinician with up to date information on some aspect of the report. Often times the reference is the publication documenting the utility of the tumor grading system or possibly a paper prognostic or treatment information. With the explosion of scientific literature, no one can keep up with all the latest findings. The addition of references to the histology report helps the clinician ensure treatment recommendations are based on the most up to date information.

Clinician to Pathologist
When the clinician reviews the histology report, questions may arise about any aspect of the report. Pathologists welcome the opportunity to discuss the report and explain an unexpected diagnosis or explain the recommended testing. Immunohistochemistry is unfamiliar to many and likely a common reason for a call to the pathologist. The attending pathologist knows the most about the biopsy and should be the first person to call with questions rather than requesting a second opinion of a different pathologist. Second opinions on histology reports appear to change the treatment recommendation in about 17% of cases referred to an oncology service at a veterinary teaching hospital.

Stage is not grade
Histologic grade is derived from histologic features that influence prognosis. Tumor stage is a clinical determination of how large a tumor is and how widely the tumor has dissemination to lymph nodes and other organs. Like histologic grade, tumor stage also helps to determine prognosis and treatment recommendations. The system most commonly used is the TNM (tumor, node, metastasis) system. In canine splenic hemangiosarcoma, stage I tumors (mass not ruptured) have a been prognosis than stage III tumors (metastasized to other organs).

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CHEMOTHERAPY OF SOLID TUMORS

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Solid tumors could also be considered nonhematopoietic tumors. Surgery is the primary therapy for this class of tumor, but chemotherapy is often recommended as an adjuvant treatment. A number of chemotherapy protocols have been recommended for various solid tumors. This presentation focuses on hemangiosarcoma, osteosarcoma and transmissible venereal tumor and will help practitioners develop skills to select the best treatment for each tumor.

The term solid tumor refers to neoplasms which are not leukemia, lymphoma or other hematopoietic tumors. Treatment of hematopoietic tumors revolves around systemic chemotherapy, but for solid tumors, surgery is the most important treatment modality. When solid tumors cannot be resected, are expected to metastasize or recur, adjuvant chemotherapy (chemotherapy in addition to surgery) frequently confers a survival benefit. This presentation will focus three common canine tumors where adjuvant chemotherapy can be beneficial.

Hemangiosarcoma, canine

Canine hemangiosarcoma is a uniformly metastatic and fatal disease occurring most commonly in the spleen, but also in the liver, right atrium, skin, bone and retroperitoneal space. In dogs undergoing surgical excision of hemangiosarcoma survival is improved over dogs not treated with surgery, but all dogs ultimately die of metastatic disease. Chemotherapy modestly prolongs survival when compared to surgery alone and is typically initiated at the time of suture removal.

Several different chemotherapy protocols for canine hemangiosarcoma have been evaluated in the postoperative setting but no particular one appears to have a survival advantage over the others. The available data suggests dogs treated with chemotherapy survival longer than dogs not receiving chemotherapy.[1] Dogs treated with surgery alone for splenic hemangiosarcoma have a median survival of about 3 months. At the Schwarzman Animal Medical Center, the typical protocol used for dogs with hemangiosarcoma is 30 mg /m^2 of doxorubicin given every 3 weeks for five treatments.[2] Epirubicin, another anthracycline antibiotic similar to doxorubicin has also been investigated in dogs with hemangiosarcoma.[3] More recently, metronomic chemotherapy protocols have been described.[4] Metronomic chemotherapy utilizes small daily doses of chemotherapy drugs rather than large doses given at less frequent intervals. Metronomic chemotherapy targets the tumor vasculature rather than the tumor cells.

Survival time reported for various chemotherapy protocols and hemangiosarcoma

	No chemotherapy Median survival (days)	Chemotherapy Median survival (days)
Epirubicin[3]	86	144
Right atrial tumors[5]	62	175

Doxorubicin compared to metronomic[4]	133 (doxorubicin)	178 (metronomic)
Doxorubicin + cyclophosphamide	NA	202
VAC	NA	172
Doxorubicin[2]	NA	172

Since no chemotherapy protocol for canine hemangiosarcoma has been shown to have superior efficacy, the selection of a chemotherapy protocol should be based on convenience, cost and drug availability.

Osteosarcoma

The most common bone tumor of dogs is osteosarcoma. Therapy involves treatment of the primary bone tumor using amputation, limb sparing surgery or radiation therapy. Amputation and limb sparing surgery treat only the local disease and do not impact the micrometastatic disease present in nearly all dogs. Following amputation or limb sparing surgery chemotherapy administration is associated with prolongation of both disease free interval and survival time. Over the past 20 years a variety of chemotherapy protocols have been investigated for canine osteosarcoma. The most recent evidence suggests carboplatin 300mg/m^2 administered every three weeks for 6 treatments results in the longest survival time with the lowest toxicity rate.[6,7]

	Median survival days
Amputation	134
Doxorubicin[8]	366
Cisplatin Doxorubicin	175, 300
Carboplatin	321, 309
Carboplatin Doxorubicin	258, 300
Randomized Carboplatin versus Carbo-Doxo[6]	451 versus 135

Virtually all dogs with osteosarcoma relapse, predominantly in lungs, but also in bone, viscera and lymph nodes. Toceranib phosphate [Palladia®] plus losartan (10 mg/kg BID) has demonstrated clinical benefit in dogs with metastatic osteosarcoma.[9] Data at this time is limited to one retrospective study. The dose reported to be efficacious is 2.7 mg/kg every other day, which is lower than the label dose of the drug.[10]

Transmissible venereal tumor

Treatment of TVT can be very rewarding since there is a high likelihood to tumor regression and long term remission in dogs treated with vincristine chemotherapy. TVT is sometimes called “sticker tumor” because the mode of transmission is direct contact of a tumor on an infected dog with the mucous membranes of another dog. High numbers of sexually intact dogs and warm climate increase the occurrence of TVT. Typically these tumors are urogenital, but can occur on the nose, in the nasal passages or oral cavity. TVT evolved from wolf DNA sometime in the last 2500 years. Tumor cells have fewer chromosomes than normal dog cells have. Diagnosis of TVT can be made with cytology or incisional biopsy. Surgical excision is not necessary since weekly treatment with vincristine 0.5 mg/m^2 IV q 7 days for two treatments past clinical remission of the tumor.[11] Multi drug protocols have been described but single agent vincristine therapy is typically efficacious and will resolve both primary and metastatic tumors.

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FELINE ANEMIA: CLINICAL PATHOLOGY AND DIAGNOSIS

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Purpose: This presentation uses a series of patients with anemia as a teaching tool to improve the general practitioners' skills in interpretation of complete blood counts (CBC).

Key Points

1. Anemia is a decrease in oxygen carrying capacity of the blood, characterized by a decreased hemoglobin, hematocrit and red blood cell count.
2. Anemia is not a diagnosis, but a manifestation of an underlying disease process. The diagnosis of anemia requires a full medical evaluation and often times, additional special testing.
3. The speaker's favorite classification scheme for anemia is the pathophysiologic method. This divides anemia into hemolytic, blood loss and decreased production (bone marrow failure).
4. Classification of anemia drives the diagnostic testing required.

Client education

Except for anemia related to trauma, the diagnosis and treatment of anemia can be a slow process. Communications with client must set a realistic timeline for testing and recovery to prevent clients from prematurely discontinuing treatment.

Classification of Anemia

Anemia can be classified several ways. Based on the presence or absence of a bone marrow response, anemia can be classified as regenerative or non-regenerative. This is helpful since decreased anemia from bone marrow failure is never a regenerative anemia. This classification may also help owner decision-making, because non-regenerative anemias are more likely to be transfusion dependant complicated by a long course of recovery when compared to regenerative anemia. Anemia has also been described based on the degree of anemia: mild, moderate and severe. Severe anemia (Hct <13%) is common in bone marrow failure and mild anemia (Hct 25-30%) more typical of anemia of inflammatory disease. Morphologic classification of anemia uses cell size (MCV) and hemoglobin content (MCH or MCHC) to describe the anemia as macro-, normo-, microcytic and hypo- or normochromic. Hyperchromic anemias do not exist because RBCs cannot synthesize an excess of hemoglobin. If the MCH and MCHC are elevated over normal, it is due to laboratory error such as hemolysis or the presence of Heinz bodies. I find this classification scheme is most useful in a few select cases such as iron deficiency anemia that is microcytic, hypochromic, FeLV related anemia that is macrocytic and normochromic or anemia of chronic disease that is normocytic and normochromic. The classification I find clinical useful in developing a diagnostic plan is the pathophysiologic method. This divides anemia into hemolytic, blood loss and decreased production (bone marrow failure) and classification requires only a CBC with a reticulocyte count, biochemistry profile, and urinalysis. Once the anemia has been classified, a differential diagnosis list and a diagnostic plan can be developed.

Red Blood Cell Evaluation

The ability of the blood to carry oxygen to the tissues is assessed in the laboratory by measurement of the RBC count, hemoglobin or hematocrit. In anemic patients, all 3 values move in parallel, decreasing by a similar amount; however, the degree of decrease is not reflected in the clinical signs. For example, a dog hit by a car with acute hemorrhage may be extremely symptomatic for anemia with a Hct of 20%. A cat with slowly progressive bone marrow failure will not even appear abnormal to the owners until the Hct falls much lower than 20%.

Evaluating Red Blood Cell Mass

Because of its universal availability, limited equipment requirements and ease of interpretation, veterinarians have typically used Hct when discussing anemia. Hgb is approximately 3 times the Hct. Red blood cell count is accurate only if the equipment has been optimized for the species being tested. Feline RBCs are small and can be counted as platelets, falsely lowering the RBC count.

Red Blood Cell Indices

Mean Corpuscular Volume (MCV) is the average side of the red blood cell. It may measured directly or be calculated by (PCV X 10)/RBC = MCV fl. Larger cells are typically immature and can indicate regeneration. Smaller cells develop in response to abnormal iron metabolism. Microcytosis and macrocytosis may also be breed specific. Mean corpuscular hemoglobin (MCH) is the Hgb/RBC X 10 = MCH pg. Mean corpuscular hemoglobin concentration is the Hgb/PCV X 100 = MCHC g/dl. Either of these is useful in determining the adequacy of cellular hemoglobin.

Macrocytosis – increased MCV

Greyhounds, normal finding, average MCV = 81 fl

Poodle macrocytosis, average MCV = 94 fl

FeLV induced anemia

B12/folate deficiency (congenital disease)

<u>Microcytosis – decreased MCV</u>

Akita, shiba inu, Jindo dog

Iron deficiency anemia

Portosystemic shunts

<u>Hypochromia- decreased MCH/MCHC</u>

Iron deficiency anemia from parasitism, gastric ulcers, gastrointestinal tumors.

Red Blood Cell Morphology

Since the advent of automated cell counting, the microscopic appearance of RBCs is less carefully evaluated than previously. Microscopic morphology can still provide clues useful in the diagnosis of anemia. Acute anemia is followed 2-4 days later by polychromasia, which is an indicator for the presence of reticulocytes and a regenerative response. Basophillic stippling is classically thought of in cases of lead poisoning, but highly regenerative anemia may also be associated with basophilic stippling. Heinz bodies are protrusions on the surface of RBCs resulting from oxidative damage to hemoglobin. Heinz bodies can occur from exposure to propylene glycol, acetaminophen (paracetamol), onions, vitamin K or diabetes. They are much more common in cats because feline hemoglobin has 8 sulfhydral groups compared to 2 in other species and the cat has a limited ability to reverse oxidative damage. Heinz bodies can also cause a false elevation in MCH.

Nucleated Red Blood Cells

The presence of nRBCs is termed normoblastemia. They do not indicate regeneration in dogs and cats as they do in ruminants. The bone marrow endothelial cells prevent release of nRBCs into circulation. In cases of anemia, the endothelial cells become hypoxic and the nRBCs are erroneously released. NRBCs can also be seen in bone marrow disease and splenic dysfunction. The presence of nRBCs without anemia suggests lead poisoning. Increased nRBCs may falsely elevate the WBC.

White Blood Cell Count

Leukocytosis is common in anemic patients. It may occur as part of a stress response, secondary to bone marrow stimulation or the presence of necrotic tissue in the body. When anemia occurs secondary to infection, the WBC is typically elevated. Leukopenia may also occur in association with anemia. It may be an indicator of bone marrow failure or neoplastic cell infiltrate in the bone marrow.

Differential Count

The differential WBC can be expressed in either absolute numbers or as a percentage of the total number. Both are useful, but care must be used in interpretation. Assessment of the percentage allows the veterinarian to see which cell type predominates but without calculating the absolute numbers, you cannot determine if the particular cell type predominates because of a lack of one cell type or a overabundance of another cell type.

For example assume a differential count of 75% lymphocytes and 25% neutrophils. If the total WBC is 2000, there are 1500 lymphocytes and 500 neutrophils. The patient should be suspect for a parvovirus infection or chemotherapy toxicity. If the total WBC is 28,000, there are 21,000 lymphocytes and 7,000 neutrophils. Diseases like Ehrlichiosis, lymphocytic leukemia and hypoadrenocorticsm should be considered.

Some diseases have a “classic” pattern on the differential count. Dogs and cats with hypoadrenocorticsm will have a lymphocytosis, and an eosinophilia. Dogs with splenic

hemangiosarcoma can have a marked leukocytosis with a mature neutrophilia as well as a regenerative anemia, nRBCs. Although most veterinarians believe patients with leukemia have a tremendously elevated WBC, in actuality, patients with leukemia may have a normal, low or high WBC. The clue is an abnormal ratio of cells and the presence of atypical cells in the peripheral circulation.

Other parameters often included in a CBC

Platelet Count

An actual count or platelet estimate is often included in the CBC since automated counting has become widespread. Changes in platelet counts are non-specific, but thrombocytopenia is often associated with anemia due to hemangiosarcoma, immune disorders and neoplastic infiltrates in the bone marrow. Marked elevation platelet counts are seen with iron deficiency anemia. The mechanism is unknown.

Reticulocytes

Immature RBCs are termed reticulocytes. They are larger, and when stained are a bluish-pink compared to mature RBCs. They are often called polychromatophillic RBCs. An increase in reticulocytes is considered a regenerative anemia. There are 2 types of reticulocytes, aggregate, which are most commonly counted and punctate which occur in cats and are not often counted in laboratories. Although many formulas can be used to assess regeneration, the presence of >50,000-60,000 reticulocytes/μl indicates regeneration. To calculate the number of reticulocytes, multiply the reticulocyte percentage by the number of red blood cells. Feline reticulocytes are difficult to count and are best counted by flow cytometry. Reticulocyte indices are better indicators of iron status than iron parameters. Reticulocyte Hb content (CH_R) and reticulocyte MCV (rMCV) are now being offered by some reference laboratories and are useful in identifying iron-deficiency in cats and dogs.

Feline Lymphoma: Frequently Asked Questions – not all have answers

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1. How has lymphoma changed over the last three decades

Since the mid-1980s, the major change has been the decline of FeLV+ cases of lymphoma which was associated with many cases of mediastinal lymphoma. Opposite of the decline of FeLV+ lymphoma, lymphoma of the gastrointestinal tract has dramatically increased. The indolent small cell gastrointestinal lymphoma was described in the early 2000s as a separate entity from the rapidly progressive large cell gastrointestinal lymphoma.

2. What hasn't changed in feline lymphoma?

The chemotherapy drugs used in the treatment of feline lymphoma have not changed much since chemotherapy protocols were first reported 30 years ago. Cyclophosphamide, vincristine, glucocorticoids and later doxorubicin was added to chemotherapy protocols. Because treatment has not changed, the prognosis and survival time are also unchanged except for cats diagnosed with nasal and small cell gastrointestinal lymphoma.

3. What is the difference between small cell and large cell lymphoma?

Valli et al described over 600 cases of feline lymphoma and found in the intestinal tract a predominance of lymphoma cells about the same size as a red blood cell. These cells invaded the mucosa and submucosa, but did not typically form a mass like is found in feline large cell intestinal lymphoma. Several clinical papers followed showing prolonged survival of these cats with minimal treatment compared to traditional multiagent chemotherapy protocols.

4. Is surgery indicated for the treatment of intestinal lymphoma?

This question is difficult to answer. The answer would require a randomized controlled clinical trial where some cats are allocated to a group that receives only chemotherapy and another that has their intestinal mass removed and then receives chemotherapy. Since that is not likely to happen, we rely on retrospective data. Once concern is if chemotherapy is successful and kills the tumor cells, will the intestinal wall perforate? Every oncologist has seen one or two cases perforate following chemotherapy, but in a study compiling cases from three specialty clinics, only 4 cases were identified. Anecdotal reports indicate some cats have longer survivals following resection and anastomosis from intestinal lymphoma, but surgery is not curative.

5. What is the best treatment for feline lymphoma?

This is the question that has no answer. What is clear from the available studies is single agent doxorubicin is not effective in feline lymphoma like it is in canine lymphoma. The other point that is clear

is that small cell gastrointestinal lymphoma needs much less treatment than large cell gastrointestinal lymphoma, but the optimal treatment for small cell gastrointestinal lymphoma has not been defined. Whether COP or CHOP should be the standard of care in cats is unknown. Assessment of the data is complicated by the fact that many of the studies analyzing these two protocols have included both small and large cell lymphoma as discussed above, the prognosis of these two forms of lymphoma are vastly different. A limited amount of data suggests radiation therapy may be useful in relapse abdominal lymphoma.

6. How do cat owners feel about chemotherapy in their cats?

Cat owners are generally positive about their experiences with chemotherapy in their cats. Over 80% would give chemotherapy to another cat if needed. About 70% felt chemotherapy improved their cat's quality of life. Owners define a good quality of life as a good appetite during chemotherapy treatment. Over 90% expected toxicity from chemotherapy. These last two pieces of information indicate veterinarians must address their plan to manage chemotherapy induced anorexia to meet owner expectations regarding quality of life.

Five chemotherapy drugs I can't live without (and you shouldn't either)

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Purpose: This presentation will focus on commonly used chemotherapy agents and their successful use in dogs and cats.

Key Points

1. The important cancers of dogs and cats treated with chemotherapy include lymphoma, mast cell tumors and osteosarcoma.
2. The small animal practitioner needs a pharmacy including chemotherapy agents known to be efficacious against these tumors.
3. Successful use requires not only the selection of the appropriate drug, but monitoring based on the adverse event profile of the drug and an understanding of the drug's mechanism of action.
4. Clinical practices to ensure patient and medical staff safety will also be discussed.

Client education

Each chemotherapy drug has a unique set of toxicities. Clients should be made aware of what clinical signs should provoke a telephone call to the clinic or a trip to the animal emergency room.

What drugs must I absolutely have in my pharmacy?

The practice of veterinary oncology requires the use of drugs effective for treatment of lymphoma, mast cell tumors and osteosarcoma. Some drugs will be used as a single agent and they may also be combined

to create a multiagent protocol. The drugs I would choose include doxorubicin, cyclophosphamide, chlorambucil, vincristine, carboplatin and vinblastine.

General guideline for chemotherapy drug use

All chemotherapy drugs have the potential to cause hematologic toxicity, some more than others and some patients may be extremely sensitive to a particular drug. To monitor for hematologic toxicity, a CBC is performed immediately before each treatment. If the neutrophil count is less than 1500/µl, chemotherapy administration is delayed. Other blood tests performed prior to chemotherapy administration are based on a drug's adverse event profile. To mitigate gastrointestinal toxicity, prescriptions for nausea and diarrhea medications are dispensed and owners instructed to give the medications at the first sign of toxicity. Exposure to chemotherapy agents can impact human health, chemotherapy drugs should be diluted and reconstituted in a biological safety cabinet using closed transfer devices and personal protective equipment in accordance with laws and safety guidelines.

Doxorubicin

Doxorubicin's broad antineoplastic profile puts it on my list of important chemotherapy drugs. Doxorubicin is effective in treating both lymphoma and osteosarcoma which are important tumors in dogs and cats. In dogs, it can induce remission and prolong survival when used as a single agent. In addition to lymphoma and osteosarcoma, it is also effective against hemangiosarcoma, mammary gland cancer and thyroid cancer. Doxorubicin is a component of the VAC chemotherapy protocol for sarcomas. Administration of doxorubicin requires placement of an IV catheter to prevent extravasation which is an adverse event to be avoided at all costs. Administration of doxorubicin should always be observed by the veterinarian or technician in case the infusion requires abrupt discontinuation to prevent extravasation. Infusion over 30 minutes (as compared to a rapid bolus infusion) decreases adverse events since the peak blood concentration [C_{max}] is lower with a 30 minute infusion and toxicity is related to C_{max}. Prophylactic administration of maropitant for 4-5 days after doxorubicin infusion decreases the occurrence of both vomiting and diarrhea. Should extravasation occur, the infusion should immediately be discontinued, the catheter left in place and any drug in the subcutaneous space aspirated. Cold compresses should be applied. Intravenously administered dexrazoxane at 10x the doxorubicin dose should then be infused through a separate catheter within 6 hours of extravasation to prevent serious tissue ulceration. In some cases multiple doses of dexrazoxane have been administered. Exact dosing schedule is unknown.

Vincristine

Vincristine's utility in lymphoma and as a single agent against transmissible venereal tumor plus its ease of administration puts it on my list of important chemotherapy drugs. It is a component of most multiagent chemotherapy protocols for lymphoma in both dogs and cats. Vincristine is a component of the VAC chemotherapy protocol for sarcomas and is also used as a component of initial therapy for immune mediated thrombocytopenia. Because of the small volume administered [<1ml in dogs and <0.3 ml in cats] placement of an intravenous catheter is not necessary; vincristine can be infused through a "butterfly" infusion set as a rapid bolus. Keep in mind vincristine is a vesicant and should not be extravasated. Should extravasation occur, the infusion should immediately be discontinued, the catheter left in place and any drug in the subcutaneous space aspirated. Warm compresses should be applied. Treatment with hyaluronidase helps to ameliorate cutaneous ulcer formation. Gastrointestinal toxicity is most common with vincristine, but is typically mild and responds to maropitant or metronidazole.

Cyclophosphamide

Because cyclophosphamide is available in both 25 and 50 mg tablets and an injectable solution and can be used to treat lymphoma, mast cell tumors and is frequently used as rescue therapy for feline relapsed small cell gastrointestinal lymphoma, it makes my list of important chemotherapy drugs. Cyclophosphamide is a component of the VAC chemotherapy protocol for sarcomas. Cyclophosphamide is not a vesicant and it can safely be administered subcutaneously, intravenously through a butterfly infusion set as a rapid bolus or orally. One of the metabolites of cyclophosphamide can cause a sterile cystitis in dogs if they are not allowed to urinate frequently for the first 24 hours following administration. To promote urination, furosemide [2.2 mg/kg IV] can be administered following cyclophosphamide and through the same catheter. Sterile cystitis from cyclophosphamide occurs rarely in cats. If cystitis occurs, the diagnosis of sterile cystitis is one of exclusion. Urinalysis, urine culture, radiography or ultrasonography are necessary to rule out bacterial cystitis and urolithiasis. Anti-inflammatory drugs may improve the dogs comfort, but complete resolution requires weeks. When dispensed to owners for home administration, owners should not crush or dissolve tablets in water, should wear gloves and wash their hands after administration. Gastrointestinal toxicity is typically mild and responds to maropitant or metronidazole. Neutropenia usually occurs within 5-7 days after administration and resolves within a week.

Chlorambucil

Because of its ease of administration, limited adverse event profile and utility in treating feline gastrointestinal small cell lymphoma, chlorambucil makes my list of important chemotherapy drugs. Closely related to cyclophosphamide, chlorambucil has also been used to treat mast cell tumors, indolent lymphoma in the dog and as an immunosuppressive agent in cats. This drug is typically dispensed for home administration. When dispensed to owners for home administration, owners should not crush or dissolve tablets in water, should wear gloves and wash their hands after administration. Multiple dose regimens have been recommended. Some regimens use pulse therapy every 7-14 days; others use continuous administration. Because the adverse event profile is limited, cats with stable medical conditions need a CBC every 4-6 weeks and a chemistry profile approximately every 12 weeks. If neutropenia or thrombocytopenia occur, chlorambucil should be immediately discontinued as permanent bone marrow damage can occur.

Carboplatin

Although several chemotherapy agents have shown equal efficacy in treating canine osteosarcoma, carboplatin, used as a single agent has the lowest adverse event profile. In addition, it can be administered as a 20-30 minute infusion, is not a vesicant and does not require pre- and post-administration fluid diuresis. Some oncologists administer this drug as an intracavitary infusion for malignant effusions. Thus, it makes my list of important chemotherapy agents in veterinary oncology. The major adverse event is neutropenia. The nadir in dogs is approximately 14 days following administration and in cats 14-25 days. Unlike cis-platin, carboplatin is not nephrotoxic, but carboplatin is excreted by the kidneys and will have increased toxicity in pet with decreased renal function.

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How I treat cancer with Palladia® (toceranib phosphate)

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What is Palladia®

Toceranib is an oral anticancer agent. Also known as a small molecule inhibitor, tyrosine kinase inhibitor or a signal transduction inhibitor, toceranib phosphate was the first anticancer drug approved for dogs.

How does Palladia® work?

Toceranib has multiple mechanisms of action. It blocks a tyrosine kinase called KIT, important in the progression of mast cell tumors and possibly gastrointestinal stromal tumor or GIST. It is also has anti-angiogenic properties through inhibition of VEGFR-2 [vascular endothelial growth factor receptor 2] and PDGFR-β [platelet derived growth factor receptor β]

What tumors does Palladia® treat?

Toceranib is approved for use in dogs with mast cell tumors, but oncologists are using it in cats and for tumors other than mast cell tumors, such as anal gland adenocarcinoma, thyroid carcinoma, oral squamous cell carcinoma, pancreatic adenocarcinoma, insulinoma, mammary gland tumors, pulmonary carcinoma and gastrointestinal stromal tumors or GIST. It has rapidly become an important drug in veterinary oncology.

How do I dose Palladia®?

Most veterinary oncologists are successfully using toceranib at approximately 2.5 - 2.7 mg/kg PO every other day or Monday, Wednesday, Friday. This dose is less than the label dose of 3.25 mg/kg EOD, but is still an efficacious dose with lower toxicity.

What precautions should owners take when administering Palladia®?

When dispensed to owners for home administration, owners should not crush or dissolve tablets in water, should wear gloves and wash their hands after administration. Small children and pregnant women should avoid any contact with the drug.

What are the adverse events associated with Palladia® administration?

Toceranib can cause a mild neutropenia, but treatment is not typically delayed because of neutropenia. The neutrophil count will rebound spontaneously even without discontinuation of toceranib. Because toceranib is administered on a continuous basis, it should be discontinued at the first sign of an adverse event such as loss of appetite, vomiting or diarrhea. If the drug is not discontinued, gastrointestinal side effects can be serious. Toceranib can cause a protein losing nephropathy and hypertension. Pancreatitis is an uncommon side effect of toceranib. The medication comes with an owner information sheet outlining side effects which should be sent home when toceranib is dispensed.

How do I monitor patients receiving Palladia®?

My monitoring plan is to schedule the initial recheck 2 weeks after starting toceranib if the pet is very ill. For pets with minimal clinical signs, I may not recheck the pet until 1 month after starting toceranib. At the two week visit, I check weight, blood pressure and confirm the owner is able to medicate their pet. For monthly visits, I check a CBC, biochemical profile, urinalysis, urine protein to creatinine ratio and blood pressure. If adverse events occur, dosage can be decreased as low 2.4 mg/kg MWF which has been shown to retain efficacy. For pets with stable clinical status, I may recheck every 6 weeks.

How do I get Palladia®?

Toceranib is manufactured and marketed by Zoetis. Some internet pharmacies stock toceranib, but beware of counterfeit medications. Tablet sizes are 10, 15 and 50 mg. Toceranib loses potency when made into a liquid. It can be compounded into smaller capsules from larger tablets in a biological safety cabinet. Owners and veterinarians should not split or crush tablets, but have a specialized compounding pharmacy make smaller dose units if necessary.

Marge Chandler

DIET IN GASTROINTESTINAL DISORDERS

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The gastrointestinal tract (GIT) is impacted directly by the diet, either positively or negatively, more than any other organ. It is affected by the nutrient content of foods, frequency and timing of meals, and dietary effect on the microbiome. The diet also has a direct effect on GI physiology, affecting motility, cell renewal rate, enzyme production, immune functions, ammonia production, and fatty acid content. It may contain toxins, allergens, nutritional excesses or deficiencies. Nutrition has a key role in the management of many GI diseases, and some may be managed by dietary therapy alone.

DIETS USED IN GI DISEASES

Companies may change food's nutrient profiles so current nutrient analyses should be obtained. Canned and dry versions of a diet and different flavours may have different nutrient profiles.

Highly Digestible, Low Residue Diets

Highly digestible (low residue) diets usually have moderate levels of highly digestible proteins and carbohydrates, low to moderate levels of fat, and reduced fibre. They are usually lactose and gluten free, although gluten allergy or intolerance appears to be uncommon in cats and dogs. They may contain antioxidants or increased omega-3 fatty acids. These diets are used for a variety of GI disorders including acute diarrhoea, rectal strictures, and chronic feline megacolon.

Novel Protein Diets, Limited Ingredient or" Hypoallergenic" Diets

These diets use single protein and usually single carbohydrate sources, often those which are not commonly used in other diets. If an adverse reaction to food (dietary sensitivity) causes GI signs it does not necessarily mean that the pet is allergic to a food ingredient as there are other causes of adverse reactions to food. There is no single recommended diet as it must be based on the pet's dietary history.The term "hypoallergenic" is meaningless when used generically (i.e. not as a specific product name) as each pet has their own ingredient sensitivities. Either a commercial or a homemade diet (single novel protein, single highly digestible carbohydrate) may be used, depending upon the animal's and owner's needs.

Exotic ingredient diets have been associated with canine dilated cardiomyopathy, although the association is not proven or well understood. It may be that some of these diets do not have good quality control (e.g. may be insufficient in taurine or other nutrients), or there may be decreased nutrient absorption due to nutrient interference or other factors. They should not be fed as a "preventative" for food allergies.

Hydrolyzed Protein Diets

Hydrolyzed protein diets contain peptides enzymatically hydrolysed from proteins to sizes ranging from 6,000 to 15,000 daltons. These smaller peptides should be less allergenic. Available diets include hydrolysed chicken, feather, salmon, and/or soy protein. Development of an antigenic response to a small part of the peptides may still be possible so a protein source different from what has been fed is a good choice.

These diets are generally highly digestible and low in fibre. Their use improves nutrient absorption and decreases antigenic exposure. Anecdotally, the response to these diets is varied, with improvement in many patients and rarely worsening of diarrhoea in some. Therapeutic diets are more likely to have sufficient hydrolysation compared to over-the-counter versions, which may not have good quality control. Therapeutic hydrolysed diets have a valuable place in determining if a GI disorder has a dietary sensitivity aspect.

Fibre Enriched Diets

Fibre enriched diets may contain the less fermentable types of fibres (e.g. cellulose) and/or more fermentable fibres (e.g. beetroot). Fibres have many attributes, including water solubility, fermentability, and degree of gel forming. The more soluble fibre types are usually the more fermentable ones. The term “crude fibre” (legally) used on pet food labels includes mostly less fermentable, less soluble, types of fibre. The terms “dietary fibre” or “total dietary fibre” is more useful and includes more of the soluble fibres.

Fibre enriched diets can be useful for cases of chronic colitis. Insoluble fibre improves faecal character and reduces exposure of the colonic epithelium to toxins. Soluble fibre improves colonic function by providing fuels from bacterial fermentation, e.g., butyrate and other short chain fatty acids, for colonocytes. Increasing dietary soluble fibre too much can result in increased flatulence and soft stools. Fibre’s gelling functions and binding of deconjugated bile acids and fatty acids can be beneficial. These benefits must be weighed against the decreased digestibility and the calorie dilution caused by increased fibre.

Large breed (>25 kg) dogs may have softer and moister faeces than small breed ones (<15 kg) even when fed the same diet. For large breed dogs it may be beneficial to limit fermentable fibre sources and to use highly digestible protein and carbohydrate sources. The inclusion of non-fermentable fibre (e.g.cellulose) may improve their stool quality.

Low-Fat Diets
Low-fat diets which are not excessively restricted in calories are available, including one in liquid form for enteral tube feeding. These diets are recommended for chronic pancreatitis and some cases of acute canine pancreatitis, hyperlipidaemia and (non-neoplastic) protein losing enteropathy, especially lymphangectasia. Feeding a low-fat diet limits the amount of circulating lipid in chymal lymphatic fluid. This decreases lacteal pressure and decreases lacteal protein loss, usually resulting in improved serum albumin concentrations.

SPECIFIC NUTRIENTS
Cobalamin (vitamin B12) and folate
Many animals with chronic enteropathy (CE) are cobalamin deficient. Cobalamin is needed for GI epithelial cell turnover and repair, and many cats’ signs won’t resolve until cobalamin has been repleted. Serum cobalamin concentrations are usually measured simultaneously with serum folate concentrations. While serum folate is often increased with CE, it potentially can become deficient when cobalamin is replaced and may also need to be supplemented. (High serum folate is a biomarker rather than a clinical concern.) Cobalamin has previously been administered parenterally, although studies now show that daily oral cobalamin supplementation is effective in normalizing serum cobalamin concentrations, including in cases with CE.

Gastrointestinal disease and vitamins
Other B vitamins can be lost in diarrhoea and supplementation may be helpful. Fat soluble vitamins, A, D, E, and K, may be lost in animals with fat malabsorption. These usually don’t need to be supplemented, although evidence for vitamin D use needs further investigation.

Omega -3 Fatty Acids
Omega-3 fatty acids are helpful with many types of inflammation. They replace some of the omega-6 fatty acids in the cell membrane and produce eicosanoids that are less inflammatory than those produced from omega-6 fatty acids as well as producing the anti-inflammatory metabolites resolvin, protectin, and maresin. For dogs and cats, fish oils are much better utilised than the plants oils. To date there have been no specific studies on omega-3 fatty acids in GI diseases in dogs and cats.

Glutamine and the gut
Glutamine is a conditionally essential amino acid, i.e. healthy animals don’t require supplementation; however, an animal in a catabolic, stressed, or starved state may need supplementation. Glutamine is an energy source for enterocytes. Supplementation may improve function and repair of the intestinal

mucosa, decrease bacterial translocation across the intestine, and improve nitrogen balance. It is most effective when provided as part of an intact protein rather than an isolated amino acid.

Prebiotics and probiotics
Prebiotics are complex carbohydrates which are fermentable, promote the growth of beneficial intestinal bacterial and thereby decrease the growth of pathogenic bacteria. Some of the prebiotics included in pet foods include fructo-oligosaccharide (FOS), mannosoligosaccharides (MOS) and inulin. A prebiotic combination (resistant starch, β-glucans and MOS) plus chondroitin added to a hydrolysed diet fed to dogs with IBD resulted in no significant differences in their clinical signs, WSAVA histologic score, or faecal microbiota, but induced improvements in selected serum biomarkers, suggesting a possible reduction in disease activity.

Probiotics are live microbial non-pathogenic cultures, e.g., Lactobacillus spp, Bifidobacteria spp, and Enterococcus spp. Probiotics (e.g., Vivomixx, Fortiflora, and others) have been found in some (but not all) studies to improve or shorten the duration of clinical signs in cats and dogs with acute or chronic diarrhoea and have also been used with fibre responsive canine colitis. Dysbiosis is a feature of chronic intestinal inflammation, so treatment affecting the microbiome is logical. A normalization of dysbiosis after long-term probiotic therapy was observed in some dogs with IBD.

It is worth noting that not all probiotics are equal – the types and amounts of microbes in products differ greatly, the quality of products varies, and one cannot extrapolate from one product to another anymore than with different antibiotics.

DIETARY MANAGEMENT OF GASTROINTESTINAL DISORDERS

Dietary indiscretion
Dietary indiscretion refers to a pet ingesting food or other substances which causes GI upset, e.g. rubbish, spoiled foods, raw meats, unaccustomed rich foods, excessive amount of new foods, or even non-food items. Toxins in spoiled foods can cause vomiting and diarrhoea. Excess amounts of rich or new foods can cause diarrhoea as the intestines are not able to absorb the nutrients and water is drawn into the intestinal lumen from the osmotic pressure of the nutrients. Dogs or cats may also ingest toxic foods such as chocolate, causing vomiting, sometimes diarrhoea, and potentially central nervous system signs. Raisin/grape toxicity can cause acute renal injury; however, the first clinical sign is often vomiting.

Dietary Management of Acute Vomiting and Diarrhoea
Previously, many cases of acute vomiting and diarrhoea were managed by withholding food for 24 hours to allow the GIT to clear the foods. While this may be needed with intractable vomiting, fasting has a negative effect on intestinal permeability and the microbiome. Enteral nutrition improves blood flow to the intestines, nourishes enterocytes, and helps support the gut immune system. Fasting does not provide bowel “rest” as the intestine continues to have intense fasting migrating motility complexes (dogs) or migrating spike complexes (cats). Parenteral fluids and electrolytes should be provided as needed and anti-emetics used after GI foreign body has been ruled out. Early enteral nutrition should be provided in most cases. A highly digestible diet should be fed. This is not a “bland diet” as the term has no meaning. (Pet foods are generally not spicy.) Probiotics have shown usefulness is the treatment of some types of acute diarrhoea.

Bilious Vomiting Syndrome
Dogs which vomit overnight may have a fasting gut dysmotility. Many of these dogs can be managed with a late night meal or snack. Metoclopramide given with the late night food is helpful for dogs which don’t respond completely to late night feeding.

Chronic diarrhoea in dogs and cats
Chronic diarrhoea, lasting longer than 2 or 3 weeks, has many potential aetiologies, including adverse reaction to food, inflammatory bowel disease/chronic enteropathy, parasites, infectious agents, neoplasia, and systemic disorders such as pancreatitis, pancreatic insufficiency, kidney or liver disease, and hypoadrenocorticism.

"Inflammatory bowel disease" (IBD) or Chronic Enteropathy (CE)
Canine and feline inflammatory bowel disease (IBD) or chronic enteropathy is a heterogeneous group of disorders characterized by persistent or recurrent gastrointestinal signs. In IBD there is an inflammatory infiltrate within the GIT. It may affect the stomach, small intestine, colon or any combination of these. The infiltration is most often lymphocytic plasmacytic, but may include eosinophils and neutrophils. It may be associated with crypt abscessation and/or lacteal dilation with protein-losing enteropathy (PLE). The underlying cause is not fully understood, and is likely multifactorial. If affecting only the small intestine, it may better be termed chronic enteropathy.

About two-thirds of canine CE cases respond to diet trial with a hydrolysed protein diet or novel ingredient diet, termed food responsive enteropathy (FRE). Hydrolysed diets may improve nutrient absorption and decrease antigenic exposure. If a pet does not respond to the first diet trial, a trial with a second (or even third) different diet (e.g. different hydrolysate or greater degree of hydrolysis) is worthwhile.

In dogs which don't respond to dietary therapy, about 16% will respond to antibiotics (e.g. metronidazole or tylosin) and about another fifth may require immunosuppressive medications (prednisolone, cyclosporine). Dogs with FRE have a better outcome than the other groups.

When a highly digestible "intestinal" diet or a hydrolysed diet was fed to dogs with chronic small intestinal disease, either diet improved signs initially; however, long-term remission at one year was better using the hydrolysed diet. Another study showed better initial outcome with a hydrolysed diet.

Clinical signs resolved in about half of 55 cats with CE fed a novel protein diet for 4 weeks, usually within 2–3 days. In about half of responding cats, there was likely an adverse reaction to food as signs recurred when they were challenged with their original diet and resolved with reintroduced of the elimination diet. The most common ingredients identified were beef, wheat and corn gluten, likely because these ingredients are commonly found in cat food. Half of the cats which responded to diet change could return to their original diet. Thirty-one of 39 dogs with FRE also did not have a recurrence of clinical signs when fed their original diet after 14 weeks of a diet trial. The high response rate of pets to a novel protein or hydrolysed diet which can then return to their original diet means that many do not have a true food allergy or intolerance. Other influences of diet include effects on gastrointestinal homeostasis, the microbiota, and immune responses.

In cats with CE, a highly digestible diet with increased protein may be also effective, regardless of fat content. The role of carbohydrates in treatment of cats with diarrhoea is less well studied.

Protein Losing Enteropathy (PLE)
Intestinal protein loss can result from many diseases, including lymphangiectasia (IL), CE, neoplasia, ulceration, intussusception, and histoplasmosis. Protein losing enteropathy should be suspected in any hypoalbuminaemic patient with no evidence of exudative protein loss (e.g. burn injury), proteinuria, or liver disease. PLE is a syndrome rather than a specific disease, so therapy should be directed at the underlying cause. The use of low-fat diets for canine lymphangiectasia, improved the clinical signs and decreased prednisolone dose for many dogs and some dogs will improve with dietary management alone.

A decrease in serum total calcium is expected with severe hypoalbuminemia as ~50% of serum calcium is bound to albumin. Additionally, low serum ionized calcium concentration occurs in association with low 25-hydroxyvitamin D and increased levels of parathyroid hormone in dogs with PLE. In dogs with PLE low serum 25(OH) D concentration is associated with poor outcome.

In dogs with a moderate to severe decrease in ionized calcium, treatment with calcium (e.g., calcium carbonate between 1 g [toy breeds] and 10 g [giant breeds] PO per dog q24h) is recommended, possibly with addition of vitamin D as calcitriol (0.03–0.06 micrograms PO q24h), if calcium treatment alone is not successful. Regular rechecks of serum ionized calcium are required for adequate

monitoring, particularly to prevent hypercalcemia. Concurrent hypomagnesemia may compromise the success of treatment and should be corrected.

ELIMINATION DIET TRIAL

For cases of CE without evidence of PLE or other serious disease, a diet trial using a hydrolysed or novel protein source is recommended, often prior to endoscopy, but after a minimum data base and faecal analysis. The diet should be highly digestible, lactose-free, contain low to moderate amounts of fat (for dogs), and reduced fibre. Yoghurt contains lactose in similar amounts to milk. While most dogs can be fed a hydrolysed protein even if sensitized to the intact protein, some will react to the hydrolysed protein, so ideally a different protein should be chosen based on the diet history.

The use of treats, snacks and food used to give medication should be discussed with the owner. Some therapeutic products, e.g. joint support supplements, contain ingredients which should not be included in the diet. Gelatin capsules may contain either beef or pork proteins and should be avoided where these proteins are to be excluded.

The duration of elimination diet trials is at least six to eight weeks for dermatological signs; however, most cases of FRE respond within two weeks. For long-term management, a commercial hydrolysed diet, limited ingredient diet, or a homemade diet formulated by a veterinary nutritionist should be fed to prevent dietary deficiencies and imbalances.

FELINE CONSTIPATION AND MEGACOLON

For constipated cats, fibre enriched diets may be beneficial in early disease stages to stimulate colonic propulsive activity, increase faecal moisture, promote colonic motility and ease of defecation. A mostly soluble fibre e.g. psyllium (ispaghula) is often useful. It should be added in small amounts initially (e.g. ½ teaspoon or less per meal) as it can cause diarrhoea. It is also present in some fibre enriched diets. In cats that have very poor colonic motility, e.g., megacolon, low residue, highly digestible diets are recommended to reduce faecal volume.

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THE ROLE OF DIET IN DERMATOLOGICAL DISORDERS

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Pet owners often perceive skin and coat condition as indicators of good nutrition and pet health. Skin conditions are among the most common reasons pet owners take their pets to the veterinary clinic.

Several nutrient deficiencies can affect the skin and incorrect dietary supplementation may unbalance a diet, e.g., in puppies, excess supplementation with calcium and/or phytates is a major cause of zinc responsive dermatosis.

SKIN AS A BARRIER AND ATOPIC DERMATITIS

One of the most important functions of the skin is as a barrier. It prevents water loss (inside-outside barrier) and protects the body from the environment (outside-inside barrier). The barrier function is dependent on the stratum corneum (SC). It has been suggested that atopic dermatitis (AD) is associated with defective barrier function. A study assessing barrier function with transepidermal water loss (TEWL, the volume of water passing from inside to outside of the body through the upper epidermal layers) found higher TEWL in dogs with AD vs controls[1]. Dogs with AD being treated had lower TEWL compared to those non-treated, suggesting skin barrier function can be improved. Nutrition is important to ensure a healthy skin barrier[2].

While canine AD is not a food responsive condition, nutritional modification can likely improve the skin barrier function. In dogs with AD, a diet fortified with antioxidants, polyphenols, and omega-3 fatty acids reduced the Canine Atopic Dermatitis Extent and Severity Index-4 (CADESI-4) scores, a severity scale for skin lesions, and owners reported a better decrease in the dog's itching compared to dogs on a control diet[3].

Little is known about AD in cats compared to dogs. The term feline atopic skin syndrome (FASS) is often used and is a component of the feline atopic syndrome (FAS). FAS is comprised of a spectrum of hypersensitivity disorders affecting the skin, gastrointestinal, and respiratory tracts. The face and ventrum are most commonly affected. Allergen-specific IgE has been detected in almost 70% of cats with non-flea, non-food hypersensitivity dermatitis suggesting an allergic component[4].

CUTANEOUS ADVERSE REACTION TO FOOD (CAFR) AND FOOD-INDUCED ATOPIC DERMATITIS (FIAD)

Many owners are concerned that food allergies cause their pet's dermatologic conditions. Many veterinary and over the counter diets are marketed as novel or "hypoallergenic", which may contribute to this misperception. There is also a myth that some breeds of dogs should be fed a "hypoallergenic" diet. Cutaneous adverse food reactions, which encompass true allergies and food intolerances, are not commonly diagnosed. The exact prevalence of CAFRs in the general canine population is unknown, but dogswith CAFRs comprised 7.6% to 12% of dogs evaluated at referral dermatology clinics.

In CAFR there is a complete response to diet restriction-provocation. In FIAD there is a partial response to diet restriction-provocation. Foods can be a trigger for FIAD, but sensitisation to environmental allergens, a poor skin barrier, and altered skin inflammation also contribute. In many pets signs start at a

fairly young age, between 1 and 4 years of age; 30 to 50% show signs before one year of age. As owners may note that there has not been a diet change, it is important to note that the foods may have been fed for 2 years or more. Clinical signs are non-seasonal, but may have seasonal flares associated with environmental allergies. Skin and GIT signs are seen in 30-60% of dogs and 10-30% of cats. Head and neck dermatitis is particularly associated with feline AFRs. Any protein can be an allergen and most dogs react to more than one ingredient. Common food allergens include beef, dairy, chicken, lamb, wheat, soy, egg, pork, fish and rice, but this is due to the frequency of feeding these ingredients, not an inherent allergenicity. Most food allergens are 10-70 kD glycoproteins[5].

DIETARY ELIMINATION TRIALS

Choosing a diet for an elimination dietary trial

Diets for an elimination trial can be home cooked or commercial (see below). Choosing novel ingredients can be difficult as owners may not remember or know what has been fed or may not know all the ingredients in foods, treats and supplements. Commercial formulation recipes can vary and some specific ingredients may not be listed. DNA from undeclared proteins has been found in 10 of 12 and in 9 of 10 tested foods, especially in over the counter foods[6,7].

Cross-reaction between food allergens

There are potential cross-reactions among food allergens which are more frequent and stronger among related allergens, including some ingredients considered “exotic”. For dogs, cross-reacting ingredients include beef and lamb and within poultry, include chicken, duck and turkey. Mammalian and avian ingredients don’t cross-react[8].

Effect of food processing on allergenicity

Food processing including heating can decrease or increase the allergenicity, generally decreasing it by destroying conformational epitopes, although the Maillard reaction (glycation when heating amino acids and reducing sugars, e.g. browning of foods) may increase it. An abstract from a small study in dogs showed raw horse meat and canned products had less proteins reacting with IgE *in vitro* compared to dry foods and cooked horse/potato; however, cooked fish proteins were less IgE reactive compared to raw fish[9] .

Food allergen serology

Only two serology tests are validated. The AvactaSensitest® IgE ELISA has a positive predictive value (PPV) of ~30% and negative predictive value (NPV) of ~80%. This means for every three dogs with a positive IgE titre only one is allergic to that food, and for every five negative dogs, four are not allergic to that food. The Cynodial® test uses Western blots of whole diets rather than individual proteins. The PPV is ~79% and the NPV is ~78%. These tests should not be used to diagnose a food allergy but may (or may not) identify suitable ingredients for diet trials[8,10] .

Home cooked foods for diet trials

Homecooked diets can be difficult and time consuming to prepare although some owners like to cook for their pet. More importantly, most homemade diets are not balanced for long term feeding. If a diet will be fed long term it should be formulated by a veterinary nutritionist. Zinc and essential fatty acids, nutrients especially important for skin health, are often deficient in diets made by owners.

Novel protein diets

Novel protein diets should contain a single protein source not previously fed to that pet. While some of these are marketed as ‘hypoallergenic’ this is only true if that pet does not react to any of the ingredients. These should be complete and balanced. If the owner has fed a variety of diets it may not be possible to find a diet with novel ingredients. Veterinary novel protein diets are a better choice than some over the counter diets as they may contain other proteins[11].

Hydrolysed diets
Hydrolysis reduces the proteins to <5-10KDa, theoretically making them non-immunogenic, although partial hydrolysation leaves larger (potentially allergenic) fragments. The degree of hydrolysis is important. Up to 50% of dogs with CAFR enrolled in three controlled studies exhibited increases in clinical signs after ingesting partial hydrolysates[12]. The greater the degree of hydrolysis, i.e. the smaller the particles, the more likely the dog will not have an allergic response. When possible avoid source proteins the pet has eaten. Different pets like different hydrolysed diets, so it is worthwhile to different foods if the first one is not accepted.

Grain and gluten
Owners are often concerned about grain and gluten. Maize, rice and wheat proteins are highly digestible. Coeliac disease has not been described in dogs and cats and allergies to gluten are uncommon in pets. In some Border terriers there is a neurological condition, Spike's disease or canine epileptoid cramping syndrome, which appears to respond to a gluten free diet. Some Irish setters had an intestinal disorder due to gluten, although this is rarely if ever seen now.

Performing dietary elimination trials
For a successful diet trial, it is necessary to explain to the owner the reason for the trial and discuss any problems they may have with exclusive feeding (e.g. other pets, family member who may not comply; scavenging or hunting). In the diet history consider flavoured medications, toothpaste, treats and scraps, dental chews, hidden ingredients, eating faeces, discarded and dropped food, and food given for medication. As owners will continue to give treats, discuss treat options, e.g. bits of the selected food, vegetables or fruit.

Compliance can be helped with short courses of glucocorticoids or oclacitinib for 3-5 days for pruritus[8]. Infections and ectoparasites should be treated prior to or during the trials. The optimum length for a food trial for dermatological signs is ≥8 weeks compared to GIT disease where signs usually respond within one to two weeks. The next response is improvement in acute and then lastly chronic skin lesions. If GIT signs are also present and haven't resolved in 2-3 weeks consider compliance problems or change the food. The pet should have a clinic appointment at the end of the trial to assess results. A food challenge will confirm the cause. Animals with AFRs should relapse within 14 days, although in one study, 60.9% of dogs with CAFR developed pruritus within 12 h of food challenge and 23.9% of the dogs developed pruritus within 3-6 hours[13].

Owners may be understandably reluctant to challenge due to fear of relapse; many owners just wish to test a few foods and treats or stay with the trial diet. If the diet is complete and balanced that may be a reasonable approach.

Food trials in cats
Some cats prefer variety and there is a risk of hepatic lipidosis if they don't eat for even a few days. Many cats will eat food from other pets or hunt outdoors, and it can be difficult to keep an outdoor cat indoors. Commercial veterinary novel protein, hydrolysed protein diets, or complete and balanced homemade diets are can be good choices and may need to be fed to all the household cats if appropriate for them.

NUTRIENT DEFICIENCIES AND SKIN DISEASE

The skin is the largest organ in the body and has a high turnover rate, so nutrient deficiencies can result in dermatopathies[5,14,15,16]. Nutrient deficiencies which can cause skin signs include protein and some amino acids, omega 6 essential fatty acids, fat soluble vitamins, B vitamins, and trace elements

including zinc. These deficiencies are unlikely in healthy pets fed complete and balanced diets. Unbalanced diets, including homemade ones, can result in any or all of these deficiencies.

Protein and amino acids

Hair is 95% protein and certain amino acids are especially important for healthy hair, e.g., methionine, cysteine, and tyrosine. Protein and amino acids provide substrates for keratinization, pigmentation, and hair growth. A substantial portion of daily protein requirements is used for skin and hair production, and protein deficiency can cause thin, dull brittle hair. Tyrosine is a precursor for melanin and a deficiency can cause a reddening of black hair.

Trace minerals

Copper serves as a cofactor in enzymatic conversion of tyrosine to melanin and a deficiency can cause changes in pigmentation.

Zinc: Zinc dependent metalloproteinases are involved in keratinocyte migration and wound healing. Syndromes are associated with zinc deficiency include lethal acrodermatitis of bull terriers, Syndrome I in huskies and malamutes, Syndrome II in puppies fed a zinc deficient diet, and "generic" dog food dermatosis.

a. Lethal acrodermatitis of bull terriers is a complete dysfunction of zinc metabolism. Signs include impaired growth, eating difficulty, crusting and scaling of the feet and pads, and splayed digits. There is no response to zinc supplementation and it has a high mortality rate.

b. Zinc-responsive dermatosis syndrome I results from a genetic defect that reduces zinc absorption and is more prevalent in Northern breed dogs (e.g. huskies, malamutes). It requires lifelong oral zinc supplementation (2-10 mg elemental zinc/kg empirically recommended).

c. Zinc-responsive dermatosis syndrome is seen in rapidly growing large-breed dogs or dogs on diets high in phytates and other zinc-binding compounds (e.g. calcium). It resolves after a change to a diet with greater zinc concentrations and/or with reduced zinc-binding compounds.

d. Dermatosis associated with a "generic" (i.e. some cheap) dog foods may be due to a relative inadequacy of zinc. Therapeutic levels (approximately1.1-2.2 mg/kg/day of elemental zinc) has been used to treat a dry, crusting dermatosis characterized on histopathology by a diffuse parakeratotic hyperkeratosis [17].

Zinc methionine supplementation to dogs with mild to moderate, chronic, AD had reduced Canine Atopic Dermatitis Lesion Index (CADLI) and in some of the dogs the dose of other medications (e.g. corticosteroids or ciclosporin) could be reduced[18].

Not all zinc supplements are the same; zinc sulfate, zinc gluconate, and zinc methionine are all acceptable but must be prescribed according to their individual concentrations of elemental zinc. Over supplementation of zinc may result in GIT upset and haemolysis, especially in cats.

Fat soluble vitamins

Vitamin A is a group of fat-soluble retinoids critical for epidermal differentiation and normal sebum production. Deficiency is uncommon but can cause skin scaling, poor hair coat, and alopecia. While vitamin A is very important for all epithelia, and deficiency results in altered skin barrier function, there are no data supporting extra supplementation to help skin barrier function.

Vitamin A–Responsive Dermatosis

Cocker spaniels are the breed most commonly affected by vitamin A responsive dermatosis, though other breeds can be rarely affected. Lesions are characterized by abnormal cornification, hyperkeratotic plaques, abnormal sebum, epidermal scaling, alopecia, and secondary pyoderma. Biopsy specimens

show orthokeratotic and follicular hyperkeratosis. Oral retinol (vitamin A) reportedly ameliorates clinical signs. The optimal dose is unknown (empiric dose is 10,000 IU/dog q24h or 1000 IU/kg q24h).

Vitamin E

Vitamin E is the primary antioxidant in the cell membrane and includes any of 4 tocopherols and 4 tocotrienols. Alpha-tocopherol is the form with greatest activity in cells, although others may be added to commercial diets as natural preservatives. Vitamin E protects fatty acids (including those in the SC) from oxidative damage Experimental deficiency causes alopecia, seborrhea, and increased cutaneous infections. In cats, a deficiency can result in pansteititis (e.g. cats fed a diet high in polyunsaturated fats as in some seafoods) resulting in firm painful swellings due to inflammation from adipose tissue perioxidation. Affected cats display reluctance to move, signs of pain and are often febrile. Dogs with atopy had lower plasma vitamin E, and supplementation (8.1 IU/kg q24 hrs for 8 wks) improved the subjective pruritus score; however, it is unknown if this relates to improvement of skin barrier function[19] .

B vitamin deficiencies

Deficiencies of biotin, riboflavin, niacin, pantothenic acid, and pyridoxine may be associated with skin disorders. There was a positive effect on TEWL of healthy dogs on a diet supplemented with pantothenic acid, niacin, choline, inositol, and histidine. These nutrients showed in vitro stimulation of ceramide synthesis in canine keratinocytes[16]. A small study in Labrador puppies fed this combination of nutrients suggested that it could help reduce itch when fed for one year[20]. There is, however, very little data on the effects of supplementing these nutrients separately and no information on how this combination improves skin barrier function.

Essential fatty acids

Essential fatty acids (EFA) include those from the omega 6 and omega 3 families.

Omega 6 EFAs are more potent than omega 3s for skin barrier function. Linoleic acid is an omega 6 EFA that is incorporated in the ceramides of the SC and deficiency results in dry, coarse skin as the epidermal barrier function of the skin depends on the linoleic acid content of the ceramides[14]. Some high fat diets or vegetable oil supplements can improve hair coat quality, although improvements are seen only with 28 days and some adaptation occurs after this time.

Essential fatty acids may improve zinc absorption. Zinc and linoleic acid supplementation together reduce TEWL. Safflower and corn oil contain the most linoleic acid; palm, olive and coconut oils are all very low in it. Oral supplementation with EFA (especially linoleic acid) may improve ceramide synthesis in dogs, although the studies are still scarce and more data are needed to confirm its effect and the appropriate route, dose and composition of the treatment[15]. For maintenance, 2% of the total caloric intake should be linoleic acid. Excessively high levels of PUFAs can interfere with the utilization of vitamin E. Even with antioxidants and good levels of EFAs, fatty acids in nearly all dry foods will become oxidized when stored for over six months.

Feeding low fat, high fibre diets (e.g. some weight loss diets) may result in a poorer quality of the coat due to the effect of some types of fibre decreasing fat absorption. This is more likely to be seen in a medium to long haired dog.

Omega-3 Fatty Acids, e.g. eicosapentanoic and docosahexaenoic acid, result in production of cytokines with less inflammatory characteristics than those derived from omega-6 EFAs. They may decrease pruritus in dogs and skin inflammatory responses in cats[21,22]. Omega 3 fatty acids originate in phytoplankton and algae, which are consumed by fish. Some fish (e.g. herring, mackerel, salmon) store these fatty acids in their muscles while others (e.g. cod) store them in their livers. Excessive dietary supplementation with cod liver oil may result in vitamin D toxicity.

MICROBIOME AND PROBIOTICS

The sequencing of bacterial 16S rRNA genes shows the human skin surface inhabited by a highly diverse and variable microbiota; similarly, dogs' skin is also inhabited by rich and diverse microbial communities[23]. Sequence data shows high individual variability. The skin microbiome also varies in different areas of the body. Some parts of the body, such as the axilla, may be less exposed to external influences and differences in hair density, sebaceous secretions or folding may create niches for certain microbes. The feline skin microbiome is likely affected by cats' grooming behaviour. This is potentially important in that the oral cavity likely influences and is influenced by the skin microbiome[24].

Allergic dogs having lower skin species richness compared to healthy dogs; cutaneous dysbiosis likely plays in the development and/or worsening of canine AD. Dysbiosis in the bacterial communities has also been observed in allergic cats[24,25]. Microbial dysbiosis of both the skin and the gut was seen in Shiba Inu dogs with AD, which may provide a basis for the potential treatment by manipulating the gut microbiota as well as the skin microbiota[26].

Probiotic products differ widely in composition and number of microbes; however, there is evidence that some products have an immunomodulatory effect. They have been suggested as an adjunct treatment for canine AD. A 10-week double-blind randomized controlled trial evaluated a novel probiotic and nutraceutical blend (PNB) in dogs with pruritis and showed improvement in owner assessed signs of itching[27]. The probiotic strain *Lactobacillus sakeiprobio*-65 given for 2 months significantly reduced the disease severity index in experimental dogs with AD[28] . The probiotic *Lactobacillus paracasei* K71 as a complementary therapy provided a corticosteroid and ciclosporine sparing effect[29]; however, *Enterococcus facium* SF68 was associated with no difference in oclacitinib dose reduction versus placebo in 21 client-owned dogs with AD[30].

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DIAGNÓSTICO POR IMAGEN DE LA MASCOTA CON TOS Y DISNEA IMAGING- DIAGNOSING THE PET WITH COUGH AND DYSPNEA

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Purpose: Develop an effective method for interpreting thoracic radiographs. **Key and Essential Points:** Gain understanding of supportive thoracic imaging techniques (echo, CT, MRI).

IMPORTANT CONSIDERATIONS

1. Thoracic radiographs are the most useful test for the coughing/dyspneic pet.
2. Remember, coughing and respiratory distress have many causes. Commonly, one or multiple comorbidities are also present.
3. Use a systematic approach to evaluate the cardiorespiratory system from the nares through the pharynx, large and small airways, lungs, interstitium, pleural space, pulmonary vasculature, and thoracic cavity. Clinical pathology, ECG, biomarkers, and other ancillary tests may provide additional information.

COUGHING

1. Cough reflex (lesions of pharynx, larynx, tracheobronchial tree, small airways).
2. Coughing may be alarming to the owner but of no clinical significance, effect quality of life, or represents a harbinger of serious disease.
3. Most coughs sound alike. More than one etiology may coexist.

DYSPNEA (RESPIRATORY DISTRESS); TACHYPNEA (RAPID BREATHING)

1. Dyspnea is difficult or labored breathing. Severity is judged by breathing effort, rate, and character. Affected dogs have a standing or sitting posture with neck extended and elbows adducted. Cats rest on their sternum, display nasal flaring, and open mouth breathing.
2. Tachypnea is increased breathing rate- with or without dyspnea.
    a. Common causes of acute dyspnea: trauma, pulmonary edema, pneumonia, airway obstruction, pneumothorax, pulmonary thromboembolism, pulmonary thromboembolism, and pleural space disease. Paroxysmal dyspnea suggests brady or tachyarrhythmias, especially with episodic weakness or syncope. Resolved dyspnea following heart drug therapy suggests CHF.
    b. Chronic dyspnea can occur from right-sided CHF, pulmonary hypertension, pericardial tamponade, broncho-interstitial disease, pleural effusion, anemia, neoplasia, hernia, others.
    c. Inspiratory dyspnea (call stridor) suggests upper airway obstruction Expiratory dyspnea suggests lower airway obstruction, parenchyma lung disease, or effusion. Common causes include congestive heart failure, chronic obstructive lung disease, other parenchymal conditions, third space diseases or neuromuscular or musculoskeletal disorders.
3. Clients may confuse coughing with gagging, wheezing, labored breathing, and reverse sneezing. Some dogs wretch or vomit after coughing or vice versa and can be misinterpreted as gastrointestinal signs. Naso-pharyngeal diseases may induce gagging, stimulating cough; these dogts may also exhibit nasal discharge, sneezing, snorting, ptyalism, or strider. Laryngeal diseases appear as strider.

CLINICAL APPROACH

Accurate diagnosis requires integration of clinical signs, medical history, physical examination, radiographic findings, and multimodal imaging including as needed. The history and physical examination help sort out underlying cause, select costefficient diagnostic tests, guide treatment options, and assess response to therapy. Determining how to diagnose and manage the coughing or dyspneic animal and formulate differential diagnoses requires selecting the most optimal diagnostic or imaging technique to begin with, accurate interpretation to generate differential diagnoses, follow-up tests, and integration with the clinical data base.

KEEP IN MIND

1. Even if one particular condition stands out from the others, a complete systematic search may identify additional or contributory factors.
2. Heart failure is not a disease, but a syndrome with highly variable clinical findings; no single feature is pathognomonic for CHF.
3. Integration of history, physical examination, laboratory and imaging tests help distinguish between heart failure and non-cardiac causes of respiratory distress.

DIAGNOSTIC IMAGING OPPORTUNITIES

Repeat radiographs (using the same technique and positioning) supply useful comparative data. Cross-sectional imaging of the chest, neck and head with CT, MRI, or ultrasonography identifies pharyngeal and nasal lesions and delineates mediastinal, hilar, pleural, in thoracic abnormalities. Diagnostic ultrasound assess cardiac structure and function, detects certain masses, evaluates for the presence and severity of pulmonary hypertension, helps detect effusions, and provides information about lung parenchyma and infiltrates.

Role of Thoracic radiography- Good quality chest films are essential for accurate diagnosis and effective management. It portrays the cardiac silhouette, airways, and lung parenchyma and thus, provides unique information not obtainable by other imaging modalities.

Radiography- Technique Images should be exposed at peak inspiration. Poorly inflated lungs will appear increased in density- i.e., 'whiter'. Breed conformation, state of respiration, obesity, relative state of hydration, stage of cardiac cycle, positioning errors and effusions alter radiographic appearances. Over-exposure causes loss of important information; under exposure causes over interpretation of lung fields.

Optimal patient positioning- superimpose the spine and sternum on the VD/DV and adjust the animal in the lateral view so that the sternum and spine are equidistant to the table top, the costochondral junctions and ribs are superimposed, the front legs are drawn forward. Align primary beam centered approximately at the 5-6th intercostal space. Oblique views greatly distort the cardiac silhouette. Avoid motion artifact. The ventrodorsal (VD) radiograph is advantageous when pleural effusion is present, (free fluid gravitates along the paravertebral gutters and does not superimpose over the heart as occurs with the DV view).

RADIOGRAPHIC INTERPRETATION-

Consider technique, variations in organ size, changes associated with breed, age, and body conformation.

Thoracic Wall The chest wall includes the spine, ribs, sternum, related soft tissues, is framed by the caudal cervical vertebrae cranially, and diaphragm caudally. Evaluate symmetry in both views (altered by pectus excavatum, scoliosis, trauma).

Mediastinum These are potential spaces between cranial and caudal pleural cavities. In the cranial mediastinum lie the heart, ascending aorta, main pulmonary artery, cranial vena cava, thoracic duct, nerves, trachea, esophagus, lymph nodes, and thymus. In the caudal mediastinum are the posterior vena cava, trachea, descending aorta, nerves, and lymph nodes. Because the mediastinum communicates with fascial planes of the neck and retroperitoneal space, pneumomediastinum may result in contrast and thus, visualization, of mediastinal structures, as well as subcutaneous edema or pneumoretroperitoneum. Widened cranial mediastinum may result from lymphadenopathy, thymoma, megaesophagus, neoplasia, or abundant mediastinal fat.

Pleural Space Potential space located between the parietal pleura and visceral (pulmonary) pleura is occupied by the lungs. Pleural thickening may allow visualization of pleural fissures. Diseases which increase pleural space opacity include pleural masses and effusions. Occasionally, effusion is loculated or trapped and involves the region of a cranial lung lobe or right middle lung lobe. Small volumes of free pleural effusion may cause blunting (rounding) of the costophrenic angles, accentuation of pleural fissure lines, and might be best visualized on the DV projection. Chronic effusions may cause pleural fibrosis. Pneumothorax decreases pleural space opacity. Overinflation can mimic pneumothorax.

Diaphragm Altered diaphragmatic symmetry may occur with diaphragmatic or peritoneal pericardial diaphragmatic hernia. Diaphragmatic hernia and pleural effusion may obscure the diaphragmatic border. Diagnostic ultrasound helps clarify these issues.

Abnormalities in Cardiac Size and Shape The cardiac silhouette is affected by breed, body conformation, and disease condition. Overestimating heart size is common with barrel-chested dogs. In deep-chested dogs the cardiac silhouette appears to be 'tall.' With obesity, pericardial fat can cause the cardiac silhouette to appear larger. The cardiac silhouette many assume a more horizontal position in geriatric cats and in barrel shaped dogs. Pleural effusions obscure the cardiac silhouette relative to the degree of effusion. Cardiomegaly usually results from congenital or acquired lesions causing volume overload (e.g. valvular insufficiency or shunts), pressure overload (e.g., valvular stenosis), myocardial disease (e.g., cardiomyopathy), pericardial disease, or respiratory conditions (e.g., cor-pulmonale). The vertebral heart scale (VHS) helps assess and monitor cardiac size but this scale, varies amongst certain breeds with bracheocephalic breeds noted for comparatively larger VHS scores.

Radiographic Lung Patterns.

Radiographic vascular patterns

- Cranial lung lobe vessels assessed from the lateral projection show that arteries are dorsal and veins are ventral to related bronchi.
- Caudal lobar vessels assessed from the VD or DV view show arteries are lateral and veins are medial to associated bronchi.

- Normally, arteries and veins are approximately the same size.
- Hypervascularity refers to arteries and/or veins which may be enlarged together in states of increased pulmonary blood flow (left-to-right shunts), high output states (thyrotoxicosis, severe anemia, fluid overload), left-sided CHF from severe mitral insufficiency or canine dilated cardiomyopathy (i.e., chronic pulmonary venous dilation with secondary pulmonary hypertension).
- Increased pulmonary artery size and shape suggest pulmonary hypertension (usually dirofilariasis; occasionally, right-to-left shunts, idiopathic pulmonary hypertension). Pulmonary venous congestion is associated with left-sided CHF.
- Hypovascularity (hypoperfusion or under circulation) creates thin arteries, veins and radiolucent interstitium and may accompany low cardiac output [shock, dehydration, caval syndrome, cardiac tamponade, acute blood loss, restrictive pericarditis, hypoadrenocorticism, severe myocardial failure), or right to left shunts

Alveolar lung patterns

- Occur when there is alveolar collapse or when alveoli are filled with blood, pus, or water. Typical findings include 1) patchy, poorly defined, increased densities with fluffy, indistinct margins which tend to coalesce, 2) air bronchograms, and 3) silhouetting of pulmonary vessels and bronchial walls by lung alveoli and interstium containing fluid. Alveolar patterns are typically fluffy and indistinct and coalesce. Cranioventral distribution is most associated with bronchopneumonia; perihilar distribution (in dogs) is most associated with CHF. Noncardiogenic edema usually occurs in dorso-caudal lung fields but can be variable. Diffuse or patchy alveolar distribution may occur with bronchopneumonia, pulmonary edema, hemorrhage (often lobar), and atelectasis.

Interstitial lung patterns

- Show up as increased nodular densities having distinct, well defined margins (e.g., neoplasia, chronic granuloma (e.g., structured pattern), or as nonspecific, localized or generalized interstitial "grayness" (e.g., non-structured pattern typical of pulmonary edema, pulmonary fibrosis, some neoplasia, interstitial pneumonia or hemorrhage), and vasculature and bronchi are blurred.

Bronchial patterns

- Result when bronchial walls become more opaque when thickened or surrounded by fluid or cellular infiltrate. Bronchial disease may progress to bronchiectasis that appears as thin-walled, cylindrical or saccular bronchial dilation with enlarged bronchial lumens that lose their distal tapering; emphysema appears as saccular or coalescing airways.

Esophagus A small amount of gas is often present in the mid thoracic esophagus. Caudal thoracic esophagus may be visualized in left lateral recumbency as a soft tissue or fluid filled structure. Aerophagia or anesthesia can result in a gas-filled distended esophagus.

Trachea Collapsing trachea (often also referred to as large airway disease) is a dynamic condition that also includes large airways.

Spinal vertebrae Older dogs may have narrowed thoracic intervertebral disc spaces.

Sternebrea Pectus excavatum causes cardiac shift (VD or DV view). Sternal malformations may accompany other congenital anomalies such as peritoneopericardial diaphragmatic hernia.

COMPUTERIZED TOMOGRAPHY

CT can demonstrate various lung disorders: lung cancer, pneumonia, emphysema, bronchiectasis, inflammation or other pleural diseases, and diffuse interstitial lung disease. CT angiography evaluates arteries, veins, and cardiac structures. CT is capable of identifying intra and extracavitary masses. CT uses shorter anesthesia time vs MRI and is less liable to motion artifact associated with MRI. CT images can often be postprocessed to highlight structures of interest.

MAGNETIC RESONANCE IMAGING (MRI)

MRI produces detailed images of organs, soft tissue, bone, and internal structures. It can assess masses including pulmonary neoplasia which cannot be assessed adequately with other imaging modalities (typically CT). It helps determine tumor size, extent, and the degree of metastasis, assess cardiac anatomy and function and its structures, determine blood flow dynamics, display lymph nodes, assess vascular and lymphatic malformations, and assess extracardiac abnormalities (vertebrae, ribs, sternum, chest wall lesions. MRI- resonance angiography (MRA) is helpful to assess vasculature. Disadvantages of MRI include its longer anesthesia time vs CT and is relatively uncommonly used for cardiac diagnosis.

ROLE OF ECHOCARDIOGRAPHY

Color-flow Doppler, 2-dimensional and M-mode echocardiography provide safe, reliable, and noninvasive information on cardiac structure and function. The echo should not replace the thoracic radiograph. Echo will not provide the cause of coughing, but certain findings can lend support to respiratory disease (eg, pulmonary hypertension), impingement by left atrial dilation of the mainstem bronchi that helps confirm radiographic findings. Standard 2-Dl and M-mode echocardiography evaluates cardiac chamber anatomy and motion and function.

Doppler Echocardiography

Doppler echocardiography permits evaluation of blood flow velocity and direction within the heart and great vessels. The Doppler shift is greatly influenced by transducer frequency. The higher the transducer frequency (e.g., 7.5MHz vs 2.5MHz), the lower the velocity of blood flow which can be measured. Sound waves which strike RBC's moving toward the transducer are reflected off the RBC's at a higher frequency. This is displayed as a spectral recording above the baseline as a positive Doppler shift. Conversely, sound waves which strike RBC's moving away from the transducer are reflected back at a lower frequency. This is displayed as a spectral recording below the baseline as a negative Doppler shift. The intercept angle, theta influences the accuracy of Doppler echo gradients. It represents the angle between the ultrasound beam and the moving red blood cells (RBC's). When Doppler echo beam alignment is parallel to moving RBC's, blood velocity is most accurately measured. If the intercept angle is wide, there will be a greater reduction in measured blood flow velocity compared with true velocity. Angles > 25^{o} generally yield unacceptable quantitative estimates of velocity. In contrast, 2-D and M-mode echocardiographic beam should be perpendicular to tissue interfaces for ideal imaging.

Estimation of Pressure Gradients

- The gradient (i.e., pressure drop) across an obstruction may be calculated by the simplified Bernoulli equation which approximates the pressure gradient across an obstruction (e.g., across a stenotic valve): pressure gradient = 4 x velocity^2. Pulsed-wave (PW) Doppler echo uses the same transducer to alternate between sending and receiving sound waves. This provides Doppler shift data selectively along the

ultrasound beam at any given range (known as range resolution). PW Doppler echo has limited ability to measure high blood flow velocities as occur frequently with acquired or congenital valvular diseases. Continuous-wave (CW) Doppler echocardiography uses separate transmitting and receiving transducer crystals to enable ultrasound waves to be continuously transmitted and received. CW Doppler echo accurately measures high blood flow velocities but is unable to selectivity sample at a given location and lacks depth discrimination. The CW beam measures Doppler shift information all along the ultrasound beam.

Color-flow (CF) Doppler echocardiography

• Combines the anatomic image of the two-dimensional or M-mode echocardiogram with Doppler blood flow characteristics to create a spatially correct, dynamic image. Blood flowing towards the transducer is coded red, and blood flowing away from the transducer is coded blue. Blood flow velocity is indicated by the intensity of the color. Slowly moving blood is colored darker; faster moving blood is colored more brightly.

Noninvasive assessment of diastolic function

- Various indices assessed by Echo and Doppler echocardiography provide important information about left ventricular (LV) and RV status in certain patients. Diastolic dysfunction is common in heart disease, particularly in feline cardiomyopathy and older cats. Mitral inflow velocity patterns, tissue Doppler parameters, strain and strain rate assessments, and a variety of other modalities are increasingly measured in conjunction with standard Dopplerderived indices and parameters.

Standard imaging planes (also called views) are designated based upon 1) transducer location (also called "windows"), 2) spatial orientation of imaging plane, and 3) recorded structures. For example, right parasternal long axis describes a view recorded with the transducer positioned on the right parasternal location and the imaging plane oriented parallel to the LV long axis.

- Right Parasternal Location- Two principal imaging planes are:1) long-axis views, and 2) short axis views. M-mode echocardiogram is derived from either the long-axis or short axis views. When recording the M-mode from short axis views, one must transect the heart in the true minor axis, avoiding angled/oblique views.
- Long-Axis Views- Two standard views include: 1) a four-chamber view with the ventricles (cardiac apex) displayed to the left and atria (cardiac base) displayed to the right, and 2) a LV inflow-outflow view obtained by slight clockwise transducer rotation showing the LV outflow tract, Ao valve and root.
- Short-Axis Views- These are obtained by rotating the transducer (and beam plane) 90° from long-axis views, then angling the beam from apex (ventral) to base (dorsal) to obtain a series of progressive views at LV apex, papillary muscles, chordae tendineae, mitral valve, and Ao valve, respectively.
- Left Cranial Parasternal Location- This is located between the left 3rd and 4th intercostal spaces between the sternum and costochondral junctions. *LongAxis Views* A series of views may be obtained with the beam plane oriented approximately parallel with the long axis of the body and heart.
- Left Caudal (Apical) Location- This location is close to the sternum between the 5th-7th ICS.
- Left Apical Four and Five Chamber Views- A four-chamber view of the heart oriented vertically may be obtained with the left heart appearing to the right and right heart to the left, and the ventricles in the near field. A left ventricular outflow region may be brought into view by tilting the beam slightly cranial from the four-chamber view. A five-chamber view shows all 4 cardiac chambers, both atrioventricular valves, and aortic valve in one plane.

- Left Apical Two-Chamber Views- When the beam plane is nearly perpendicular to the long body axis and parallel to the long cardiac axis a twochamber long axis view is obtained of the LA, mitral valve, and left ventricle.

'Cage-side' Ultrasound (T-fast, A-fast)

- Increasingly, T and A-fast scanning has been applied to provide useful information in emergency situations including reliable and accurate assessment for diagnosing lung infiltrates associated with pneumonia and pulmonary edema in emergency settings. Advantages are its fast, non-invasive, and radiation-free method to provide ancillary diagnosis.

CARDIOMIOPATÍAS FELINAS: CÓMO DIAGNOSTICARLAS Y TRATARLAS

FELINE CARDIOMYOPATHIES: HOW TO DIAGNOSE AND TREAT

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Purpose: Teach a clinical based approach for diagnosing, staging, treating, and follow-up care of cats with cardiomyopathy.

Key and Essential Points:
Interpret imaging test tests with all available diagnostic information- history, examination, ECG, radiography, ultrasound, biomarkers, clinical pathology, SBP; identify animals at risk for cardiovascular morbidity; review management options; treat acute and chronic congestive heart failure; incorporate new recommendations from the ACVIM Consensus Statement Guidelines for the Classification, Diagnosis, and Management of Cardiomyopathis in Cats (JVIM 2020).

OVERVIEW

Cardiomyopathy is the most common form of feline heart disease and accounts for 95% of cardiac morbidity and mortality. Cardiomyopathies represent a diverse and heterogeneous group of heart muscle disorders not caused by valvular, vascular, congenital, or systemic conditions. Clinical phenotypes often change (remodel) over time and some hearts express attributes that overlap with other diseases. In humans more than 1500 mutations have been detected in HCM. In the cat only two have been identified. The presence of HCM represents a significant health burden, contributes to all-cause mortality, and reduced survival.

UPDATE from ACVIM Consensus Statement Guidelines

Luis Fuentes V, Abbott J, Chetboul V, Côté E, Fox PR, Häggström J, Kittleson MD, Schober K, Stern JA. ACVIM consensus statement guidelines for the classification, diagnosis, and management of cardiomyopathies in cats. J Vet Intern Med. 2020 Apr

3. doi: 10.1111/jvim.15745. [Epub ahead of print]

TERMINOLOGY AND CLASSIFICATION

Diagnostic classification is complicated. Structural and functional phenotypes can change over time, overlaps with other diseases, and may not conform to strict definitions! Four classic forms of cardiomyopathy (CM) help provide the best
"snapshot" of cardiac structure:

1. Hypertrophic (HCM)- hypertrophied, non-dilated LV (IVS or LV wall at end diastole ≥ 6mm thick) in absence of clinical disease capable of inducing the magnitude of LV hypertrophy (no aortic stenosis, severe systemic hypertension, or hyperthyroid state). Many cases of HCM have the additional distinction of dynamic left ventricular outflow tract obstruction during systole, termed hypertrophic obstructive cardiomyopathy (HOCM). Often, this distinction is vague; at rest such cats may not display dynamic obstruction whereas with excitement, this feature becomes apparent.
2. Restrictive (RCM)
    a. Classic, nonendomyocardial form: Severe, bi-atrial dilation in absence severe volume overload (eg, no shunts or severe Mitral or Tricuspid regurgitation); relatively normal LV and RV cavities; normal or mild LV hypertrophy; and restrictive diastolic LV filling (eg, high E:A ratio [>2.5:1] and reduced mitral E deceleration time [<65msec]).
    b. Endomyocaridal form: Prominent endocardial scarring (hyperechoic echo lesions) bridging the ventricular septum and LV free wall, or obliterating or partially attenuating the LV apical region, and/or mid-left ventricular region; mild to moderate LVH; severe LAE; Doppler echo findings of diastolic dysfunction.
3. Dilated (DCM)- LV dilation (LVs>12mm, LVd>20mm), systolic failure (%FS<25%), thin LV walls.
4. Arrhythmic cardiomyopathy (also termed arrhythmogenic RV cardiomyopathy [ARVC] or dysplasia [ARVD])- severe RVE, often thin RV walls, abnormal RV pectination, RA enlargement, and variable LA and LV changes. Many affected cats have substantial tricuspid regurgitation.
5. Cardiomyopathy with nonspecific phenotype (formerly called 'unclassified cardiomyopathy')
    a. Add relevant structural and functional descriptions- for example, cardiomyopathy with nonspecific phenotype characterized by apical, LV thinning, focal basal hypertrophy, diastolic dysfunction, etc.

CLINICAL FINDINGS

Systolic heart murmurs are common in cats- some estimate up to 40% of normal cats have a heart murmur. Most but not all cats with cardiomyopathy have heart murmurs. Gallup sounds including third and fourth heart sounds are sometimes detected in cardiomyopathic cats even in preclinical stages, and the presence of these sounds are never normal. Some affected cats will have arrhythmias and in fact, infrequent ventricular premature complexes are relatively common in cats with preclinical as well as decompensated disease. Clinical signs are apparent when a cat decompensates, including acute respiratory distress due to CHF, acute paralysis from arterial thromboembolism, or occasionally, sudden death. Pulmonary edema is the most common manifestation, followed by pleural effusion, with pericardial and abdominal effusion occurring much less frequently.

DIAGNOSIS

Discriminating Cardiac vs Respiratory Cause of Dyspnea- Thoracic radiography documents change consistent with CHF (e.g., cardiomegaly and patchy, diffuse or focal pulmonary interstitial and alveolar infiltrates), detect effusions, masses, and other non-cardiac conditions. Thoracic radiography can indicate changes (enlargement patterns, altered cardiac silhouette) and helps to document CHF (effusions, lung infiltrates) and identify non-cardiac conditions. However, radiographic cardiac findings do not substitute for echocardiography.

Echocardiography is the gold standard for assessing cardiac structure and function and characterizing the form of underlying myocardial disease. Heart murmur is not a sensitive marker of heart disease and some studies report that up to 40% of normal, healthy cats have soft heart murmurs. Gallop heart sounds may be detected by auscultation and are never normal. A fourth (S4) gallop sound may be detected in some cats with HCM, while a third (S3) gallop sound is usually associated with dilated cardiomyopathy. Atrial or ventricular premature complexes are often detected however overall, electrocardiography is insensitive for detecting heart disease.

Noninvasive blood pressure measurement identifies systemic hypertension which can increase left ventricular wall thickness, especially with chronic renal failure and hyperthyroidism. Serum T4 (in cats older than six years of age) and PCV are important. Measurement of serum troponin concentration may have value when indicated, suggesting acute cardiac injury, although at present, sensitivity and specificity are relatively low for cardiomyopathy, per se. High sensitivity and specificity using a commercial blood test to measure the cardiac biomarker, NTproBNP has made this useful an adjunct test to help differentiate cardiac vs noncardiac causes of respiratory distress. Moreover, assessment of NT-proBNP concentration in combination with conventional evaluation such as radiography and electrocardiography has been reported to significantly improve the accuracy and confidence of general practitioners to distinguish cats with primary respiratory disease from those with CHF. Diagnostic accuracy is improved when NT-proBNP assay is used in conjunction with other tests such as physical examination, ECG, radiography, and echocardiography. The snap test was designed to differentiate cats with moderate to severe LVH from cats with normal or equivocal or mild LVH, but was not designed to diagnose CHF and should be avoided for this specific application.

THE PRECLINICAL (ASYMPTOMATIC) CAT

Cats with preclinical hypertrophic cardiomyopathy are at substantial risk for developing cardiac morbidity and mortality. The epidemiology of preclinical HCM has recently been described from 1730 cats (1008 HCM/HOCM and 722 apparently healthy cats without heart disease (Fox et al., REVEAL Study. JVIM, 2018). During the study period, CHF, ATE, or both occurred in 30.5% and cardiovascular death in 27.9% of 1008 HCM/HOCM cats. Risk assessed at 1, 5, and 10 years after study entry was 7.0%/3.5%, 19.9%/9.7%, and 23.9%/11.3% for CHF/ATE, and 6.7%, 22.8%, and 28.3% for cardiovascular death, respectively. There were no statistically significant differences between HOCM compared with HCM for cardiovascular morbidity or mortality, time from diagnosis to development of morbidity, or cardiovascular survival. Cats that developed cardiovascular morbidity had short survival (mean+/-standard deviation, 1.3+/-1.7 years). Overall, prolonged longevity was recorded in a minority of preclinical HCM/HOCM cats with 10% reaching 9-15 years. Thus, preclinical feline HCM/HOCM is a global health problem in these animals that carries substantial risk for CHF, ATE, and cardiovascular death.

There is no current evidence that treating asymptomatic cats prevents cardiac disease progression, reduces risk of cardiac morbidity, or prolongs cardiac survival. Certain findings merit concern for increased risk of cardiovascular morbidity and such risk factors may provide grounds for treatment deliberation.

POTENTIAL CARDIOVASCULAR RISK FACTORS

Certain myocardial structural or functional abnormalities may predispose to adverse outcome, providing *raison d'être* for pharmacologic intervention. *Efficacy treatment of preclinical cases remains unproven*.

Myocardial Infarction/thin myocardial segments (remodelling0 This is inferred by thinned, hypokinetic LV wall segments seen by echocardiography. Such cases have used ACEI or beta-blockers based upon the use of these drugs in humans to mitigate ventricular remodeling and reduce mortality.

Tachyarrhythmia Rapid tachyarrhythmias can reduce cardiac filling, promote ischemia, and result in hemodynamic instability. Sustained tachyarrhythmias are usually associated with myocardial disease (myocyte necrosis, fibrosis, inflammation, interstitial matrix changes). Antiarrhythmic therapy is administered in selected cases to control ventricular rate.

Severe LV Hypertrophy Cats with greatly increased LV mass (diastolic septal or LV wall thickness > 8mm) may be at increased risk for cardiovascular events.

Severe Left Atrial Dilation This contributes to blood stasis and thrombus formation.

Restrictive LV Filling Pattern (Restrictive Physiology) Doppler echocardiographic evidence of a restrictive trans-mitral filling may suggest endstage diastolic dysfunction and carries poor prognosis. This physiology may occur in any form of cardiomyopathy.

Spontaneous Echo Contrast ("Smoke") Associated with blood stasis and presage increased thromboembolic risk, this finding merits consideration for antiplatelet drug therapy.

Myocardial Failure In some HCM and RCM and in DCM cats LV contractility is reduced (e.g., fractional shortening <25%; LV end-systolic dimension >12 mm). Potential therapies include oral taurine supplementation, ACEI, pimobendan, and treatment of tachyarrhythmia if present.

Arrhythmic Right Ventricular Cardiomyopathy Cats with advanced structural lesions (e.g., severe RV/RA dilation, ventricular tachycardia) are at risk for CHF. ACE inhibitors and pimobendan should be considered with advanced lesions.

"Malignant" Familial History of Sudden Death (High Risk Genotype) Pedigrees may be identified with a documented heritable pattern of HCM and severe morbidity and mortality (e.g., Maine coon cats, others). More aggressive monitoring and focused, individualized therapies should be considered.

Hypertrophic Obstructive Cardiomyopathy (HOCM) by itself does not confer higher risk than cats with the non-obstructive form of Hypertrophic

Cardiomyopathy (HCM) and thus, HOCM cats do not automatically merit more aggressive therapy.

GOALS FOR MANAGING HEART DISEASE

There is no single test that reliably identifies the failing heart (heart failure is a syndrome, not a disease). Diagnosis requires an integrated approach with findings from medical history, clinical signs, imaging, and clinical testing. Aims of management are reduce morbidity, assure quality of life, increase survival.

Managing Acute Congestive Heart Failure with Predominantly Pulmonary Edema (HCM)

Pulmonary edema is life threatening.

- Diuretics represent the cornerstone for acute, emergency management and are administered as intermittent IV bolus, or by constant rate infusion. Initial IV bolus of furosemide (1- 2 mg/kg IV) is given and repeated if needed in 1-2 hrs; 1 mg/kg IV is administered every 8-12 hours until evidence of reduced lung crackles, improved breathing rate and effort are observed, at which time furosemide dose is briskly reduced. Alternatively, furosemide is administered by continuous infusion (0.25 – 0.35 mg/kg/hr) following an initial IV bolus. There is
  no proof that IV bolus or continuous infusion is superior.
- Changing from furosemide to torsemide (1.25mg/4.5mg cat once-twice daily) is performed for recurrent, diuretic resistant chf.
- Thoracocentesis is performed when substantial pleural effusion is present
- Some clinicians add pimobendan, 1.25 mg Q 12 hours while others reserve this for resistant or recurrent CHF.
- Supplemental oxygen (40-60% O_2- enriched inspired gas) improves pulmonary gas exchange.

- Trans-dermal 2% nitroglycerin ointment, ¼ to ½ inch q 6hr can be added for the first day or two in severely affected cases safely, although this therapy has become less popular.
- Clopidogrel (18.75 mg daily) is administered to cats at risk for thromboembolism (eg, large atrium, blood stasis, myocardial failure). Aspirin is less effective (10-20 mg PO q 3 days).
- Angiotensin converting enzyme inhibitors (ACEI) such as enalapril [1.25-2.5mg q 24 hr] can be added, usually at first recheck if renal function is normal.
- Diagnostic tests should include a CBC/differential and biochemical profile (with T4 when cats are greater than seven years of age). Renal function and electrolytes should be tested at least every day during hospitalization since acute kidney injury and electrolyte loss can occur owing to the sensitivity of cats to furosemide. ECG is performed if rhythm disturbance is detected
- Systolic blood pressure should be monitored during hospitalization
- Diagnosis should be confirmed via echocardiography
- Radiographic clearing of alveolar infiltrates usually takes 24 to 36 hrs post therapy in first time heart failure cases.
- Dehydration, azotemia, and hypokalemia can result from over-diuresis. Close monitoring of creatinine and electrolytes is important. Appetite stimulants should be administered if anorexia is present.

Managing Acute Heart Failure Associated with Systolic Dysfunction (DCM) Although uncommon, some cats present with CHF associated with reduced LV contractility and LV dilation. Taurine deficiency, once common, has become an exceedingly rare and etiology is usually unknown. In some cases, DCM may develop as an end-stage consequence of HCM or RCM.

Decompensated cats present with pulmonary edema, effusions or both in conjunction with hypothermia and often, cardiogenic shock. Therapies include the following:

- Centesis it is performed as needed if plural, pericardial, or abdominal effusion is present and it is interfering with breathing or cardiac function Pimobendan (1.25 – 2.5mg PO q 2 hours)
- Dobutamine (2-5 mcg per kilogram per minute constant rate infusion) is added if cardiogenic shock is present.
- Judicious furosemide administration is titrated to patient needs and briskly reduced or stopped once pulmonary edema as resolved.
- .Clopidogrel (1/4 of a 75 mg tablet orally every 24 hours) because heart failure cats are at risk for thromboembolism.
- (Generalized support is added including supplemental oxygen, assessing kidney function and electrolyte concentrations.
- Supplemental feeding via nasoesophageal tube can be considered if anorexia persists despite appetite stimulant medication.
- Diuretics I reduced to the lowest effective dose, pimobendan his continued, and consideration is given to adding an ACEI. Many supplement the diet with taurine, 250 mg twice daily if they cannot obtain a blood taurine level.
- For refractory effusions, judicious use of hydrochlorthiazide (6.25mg q 24-48 hrs) and an ACE inhibitor (enalapril, benazepril, ramipril, etc) it is considered when renal function is preserved and patient status is stable.
- Long-term prognosis is guarded. Historically, taurine deficiency was the most common cause of DCM. Following the reported link with dietary taurine deficiency in 1987, taurine related DCM is now rare. However, cases of idiopathic DCM are still detected.

Managing Chronic Heart Failure

Chronic therapy is individualized to maintain a congestion-free state; prevent arterial thromboembolism; halt, slow, or reverse myocardial dysfunction (theoretically); promote quality of life; and prolong survival. It is essential to identify and treat contributory diseases (e.g., systemic hypertension, hyperthyroidism, and anemia) and other comorbidities if present. Complete database is helpful including comprehensive clinical pathology testing.

Furosemide is decreased to the lowest effective dosage. Some cats remain stable on 1- 2 mg/kg PO given daily or every other day while in others, diuretics may need to be used twice daily, or switch to torsemide. For cats that have the obstructive form of hypertrophic cardiomyopathy (HOCM), recent data shows that these cats are at no greater risk compared to HCM. There is no data to suggest that beta blocker therapy is beneficial and thus, these agents are not routinely recommended to treat HOCM anymore. The use of pimobendan is controversial with some clinicians prescribing it long term and others not prescribing it until recurrent heart failure. Animals should be reevaluated every 3 to 4 months to assess overall health and renal function, heart rate and rhythm, and once or possibly twice yearly, repeat echocardiogram to look for change of significant remodeling. Affected cats are at risk for recurrent heart failure and thromboembolism.

RECURRENT OR RESISTANT HEART FAILURE

Comprehensive patient evaluation helps to identify and manage renal failure, hyperthyroidism, anemia, arrhythmias, and other systemic or metabolic conditions that can trigger or predispose to cardiac decompensation.

- Diuretic resistance may occur as heart failure progresses, and upward furosemide dose titration may be indicated.
- Some cats appeared to respond favorably when furosemide is substituted for with torsemide, starting at 0.1 mg per kilogram orally daily and titrating the dose upward or to twice daily administration. This therapy is individualized to each cat based upon its renal status, appetite, and in consideration of other drugs being given.
- Addition of a second diuretic (e.g., thiazide-5 to 10 mg every other day) is reserved for cases of persistent diuretic resistance that did not respond to torsemide.
- Arterial blood pressure and thyroid status should be reassessed periodically
  as well as CBC/deaf and biochemical profile to check for comorbidities and treatable conditions.

ADDITIONAL UPDATES FROM ACVIM CONSENSUS STATEMENT GUIDELINES (SEE AT END OF THESE NOTES)

Luis Fuentes V, Abbott J, Chetboul V, Côté E, Fox PR, Häggström J, Kittleson MD, Schober K, Stern JA. ACVIM consensus statement guidelines for the classification, diagnosis, and management of cardiomyopathies in cats. J Vet Intern Med. 2020 Apr

3. doi: 10.1111/jvim.15745. [Epub ahead of print]

A. Cardiomyopathy classification should focus on phenotype and staging focuses more on risk assessment and management.

B. Echocardiography is a goal standard for diagnosis. In cases of respiratory distress, even simple, focused, point-of-care ultrasound examination can help identify cats at high risk of CHF or ATE.

C. A new staging system for cardiomyopathy in cats was developed:
   a. stage A – cats were predisposed to cardiomyopathy but have no evidence of myocardial disease
   b. Stage B – describes cats with cardiomyopathy but without clinical signs and is further divided into stage BI – cats at low risk of imminent congestive heart failure or arterial thromboembolism and stage BII – cats at high risk of imminent CHF or ATE
      i. left atrial size is a prognostic marker. The more severe left atrial enlargement, the higher risk for CHF and ATE
   c. Stage C – cats who have developed CHF or ATE
   d. Stage D – cats who are refractory to CHF therapy. D. Risk increases proportionately from Stage A to Stage D.

E. Evidence-based recommendations are based upon diagnosis and presence, absence, and severity of clinical signs.

   a. Stage A cats do not require therapy but rather, monitoring, usually by echocardiography if evidence of a heart murmur or gallop rhythm or arrhythmia develop.
   b. Stage B cats may be considered for therapies based upon the magnitude of cardiac structural and functional abnormalities detected.
      i. B1 cats are usually monitored annually for development of severe left atrial enlargement
      ii. B2 cats are generally defined by moderate to severe left atrial enlargement as well as other remodeling changes. Cats with severe atrial enlargement or with atrial enlargement in the presence of spontaneous echo contrast (smoke) are often considered for antiplatelet aggregating therapy including clopidogrel. There is no evidence that beta-blockers or ACE inhibitors provide any benefit.
      iii. Cats with HOCM are not automatically treated with betablockers simply because they have dynamic LV outflow tract obstruction as there is no evidence to support any clinical benefit forbade a blockade in these patients. Occasionally, cats with HOCM are presented for exercise induced syncope and such cats are generally administered beta-blockers.
   c. Stage C cats, indicated by CHF are initially treated with IV diuretics and
      if this next, supplemental oxygen therapy; all effort should be taken to minimize stress. Severely affected cats may not be able to tolerate thoracic radiography and were ultrasound is available, point-of-care ultrasound can provide valuable information. Centesis is performed when substantial fluid accumulations develop in the chest, abdomen, or pericardial sac. Cats with low cardiac output signs (hypotension, hypothermia, bradycardia) can be administered pimobendan and potentially dobutamine CRI infusion.

   d. Stage C cats indicate refractory heart failure despite high doses of furosemide. Such cats may be administered spironolactone, pimobendan, change from furosemide to torsemide, consider ancillary supplementation with a thiazide diuretic, repeat blood chemistries, hemogram, T4 test, systolic blood pressure measurement, repeat echocardiogram, and potentially other tests.
   e. Development of ATE is associated with dire outcomes. Affected cats benefit from analgesia, anticoagulant therapy using low molecular weight heparin, or a factor Xa inhibitor as soon as possible. All cats received clopidogrel.

LA HISTORIA MÉDICA Y EL EXAMEN FÍSICO- DECISIONES DE VIDA Y MUERTE,

MEDICAL HISTORY AND PHYSICAL EXAMINATON'S ROLE- LIFE AND DEATH DECISIONS

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Purpose: 1) Learn essential elements of medical history taking, **2**) develop expertise performing physical examination, **3**) understand how to identify medical context from these evaluations that improve diagnosing patient illnesses; identify owner concerns; and help interpret diagnostic testing.

Key and Essential Points: To extract a medical history, spend time to listen to the owner. Then use focused questions. First, observe the pet before placing it on the exam table; develop a comprehensive examination technique to consistently evaluate the entire patient. Auscultate in a quiet room (spend time learning heart and lung sounds- use the internet or commercially produced video and sound CDs). Develop criteria to relate history with physical examination findings. Be thorough. Be consistent!

The medical history and examination are the bedrock upon which all diagnoses and therapies are based.

To succeed, develop a consistent and systemic approach to evaluate the

cardiorespiratory system- from the nares through the pharynx, large and small airways, lungs, pleural space, mediastinum, pulmonary vasculature, and heart. This will guide diagnostic testing, help detect masses, foreign bodies; certain parasites; toxins, lung disease, pulmonary hypertension; congenital heart disease, CHF and arrhythmias.

DO FIRST THINGS FIRST

1. Observe dyspneic patients immediately; note the RR/effort; does pet need immediate intervention?
2. Triage/stabilize, then conduct a more comprehensive evaluation.
3. As soon as possible, ask owner- what are their observations and concerns– what is the emergency?
4. For non-emergency visits, start with a well-planned list of questions.
   a. What is the reason for the visit, what are the chief pet owner concerns?
   b. What are the symptoms? Acute or chronic? Their chronology and severity?
   c. Does exercise, cough, excitement precipitate symptoms?
   d. Has pet been treated for this condition before? With what drugs and doses? Response?
5. Have any diagnostic tests been performed at other veterinary hospitals? Provide results or contact information to acquire this data?

FREQUENTLY ASKED CLIENT QUESTIONS

1. What causes coughing and breathing distress?
    a. Consider cardiopulmonary conditions, upper and lower airway diseases, foreign bodies, allergies, CHF, lung disease (eg, pneumonia), effusions.
    b. Use a consistent, detailed diagnostic approach to generate differential diagnoses and guide diagnostic testing and risk assessment.
2. Is there one best test to start with?
    a. Often, a chest radiograph is the best start (assuming pet is stable enough).
    b. Echocardiography is not sensitive to identifying or discriminate between causes of coughing
    c. In critical patients, point of care lung ultrasound can complement history and physical examination, identify pleural effusion, lung metastasis, pneumothorax, and lung infiltrates.
    d. Comorbidities are common. A complete systematic search may identify additional or contributory factors even if one particular condition appears to stand out.
3. What is the best test to detect congestive heart failure (CHF)?
    a. Heart failure is not a disease, but a syndrome.
    b. It causes highly variable clinical findings. No single feature is pathognomonic.
    c. Diagnosing CHF is aided by integrating the history, physical examination, diagnostic imaging (most importantly, chest radiographs and echocardiography), and selected clinical pathology tests to distinguish between cardiac and noncardiac causes of respiratory distress, or to identify and assess contributions of these conditions to clinical signs.

OVERVIEW

Cough or respiratory distress are common presenting problems. Medical history and physical examination skills help detect underlying cause(s) of symptoms, choose the most cost-efficient diagnostic tests tailored to that patient, assess prognosis, guide treatment, and gauge response to therapy.

Remember – cardiorespiratory distress has many potential causes. One must be thorough and consider conditions throughout the cardiopulmonary system.

Comorbidities are common so don't stop your evaluation if you identify what appears to be a major disease or condition!

HISTORY

Take your time and be thorough. The medical history helps reveal conditions and diseases causing clinical signs. It is also an indispensable tool for establishing a trusting doctor-client relationship.

The history may capture irrelevant facts, but offers a glimpse of the client's emotional state, health care experience, observational skills, and gives the client the satisfaction of being heard. Remember – the pet owner will not always volunteer all relevant information due to incomplete or misinterpretation of clinical signs, emotional status, and denial of serious illness). It is your role to uncover this information.

Past History Review any available diagnostic tests and procedures (radiographs,

ECG's, echocardiograms, clinical pathology) from other veterinary practices before the visit if possible. Congenital heart disease may be implied if siblings, dam or sire are also affected. Drugs may have been already prescribed, and knowledge of doses, compliance and therapeutic response can offer valuable insights. Knowledge of past medical and surgical conditions, body condition, travel history, diet, and vaccination status provide important background data regarding the state of health and illness.

Signalment Many diseases have age, breed and sex predilections that assist diagnosis.

Comprehensive Current Cardiopulmonary History Ask the owner if they have noticed rapid breathing (tachypnea), dyspnea, excitement related respiratory induced breathing distress, exercise intolerance, syncope, coughing, or cyanosis. These signs can result from cardiac and respiratory disease. The following historical information can imply certain disease states:

1. Dyspnea.
   - Acute dyspnea can attend pulmonary edema, pneumonia, airway obstruction, pneumothorax, pulmonary thromboembolism, exacerbation of pulmonary hypertension, foreign body, trauma.
   - Chronic, progressive dyspnea may occur with right-sided CHF, pericardial disease, bronchial or parenchymal lung disease, pleural effusions or pleural space diseases, anemia, or neoplasia.
   - Inspiratory dyspnea suggests upper airway obstruction.
   - Exertional dyspnea suggests lower airway obstruction and can also be associated with organic cardiac disease (e.g., CHF) or severe respiratory disease.
   - Dyspnea at rest can indicate pneumothorax, pulmonary thromboembolism, pneumonia, CHF, or severe pleural space disease (such as effusions).
   - Paroxysmal dyspnea in a pet without other respiratory signs may suggest brady- or tachyarrhythmias, especially when accompanied by episodic weakness or syncope.
   - Resolved dyspnea following cardiac drug therapy supports CHF.
   - Cats with pulmonary edema will display acute tachypnea, flaring nostrils, and open mouth breathing.
2. Cough
   - Most coughs sound alike and more than one etiology may coexist.
   - Cats with pulmonary edema rarely cough
   - Dogs with pulmonary edema (CHF)
     - Cardiogenic pulmonary edema frequently results from left-heart volume overload (mitral regurgitation due to chronic, myxomatous valve disease [or left to right shunting PDA, a rare occurrence]), or from dilated cardiomyopathy.
     - Coughing will not always occur or be reported.
     - Acute, edema-related cough or respiratory distress is generally a recent, rapidly progressive finding, often less than 1-2 days duration; coughing when occurs, is relatively soft, accompanies tachypnea at rest, and exertional dyspnea (in contrast to large airway disease, below).
     - When edema is fulminate, soft, short coughs may yield small quantities of frothy, pink-tinged edema foam from the mouth or nares; affected dogs often extend the neck, are in duress, and gasp for air. Flaring of the nostril are often displayed in affected cats.
     - Large airway disease-induced cough is harsh, resonant, 'dry,' 'goose honking'; chronic; paroxysmal; elicited by excitement/activity. Persists for years. Dogs usually have normal exercise capacity. Impingement of the left main stem bronchus by an enlarged left atrium from chronic mitral regurgitation may contribute to chronic coughing.
     - Dogs with severe pulmonary hypertension may have lung infiltrates, cough, collapse, lung crackles.
     - Cats rarely cough with pulmonary edema- rule out asthma, bronchial disease ▫ Syncope.
     - Can result from transient loss of consciousness from inadequate cerebral blood flow.

- ✦ May follow coughing or excitement in small breed dogs with chronic, severe mitral regurgitation, who's paroxysmal cough is immediately followed by transient collapse ('cough syncope'); severe sub-aortic stenosis (SAS) or pulmonic stenosis (PS); severe pulmonary hypertension (PHT), right-to-left cardiac shunts (tetralogy of Fallot, patent ductus arteriosus [PDA]), and tachy- or bradyarrhythmias (e.g., sick sinus syndrome or SA node dysfunction, high grade AV block), or hypertrophic obstructive cardiomyopathy (feline).
- ✦ Noncardiac causes include upper and lower airway disease, pulmonary hypertension, and parasites such as heartworm and other long parasites.

3. Shortness of breath, weakness, exercise intolerance.
   - Decompensated heart failure causes lack of exercise ability, lethargy, or fatigue. So can obstruction to ventricular outflow, cardiac tamponade, severe SAS, PS, PHT, and arrhythmias. Other disorders including anemia, systemic and metabolic diseases (e.g., hypotension, hypoadrenocorticism), neuromuscular and orthopedic diseases, and a host of respiratory diseases.

PHYSICAL EXAMINATION Perform a complete review of all systems including HEENT (head, eyes, ears, nose, throat), neurologic, gastrointestinal, urinary, endocrine, hematologic, vascular, musculoskeletal, cardiac, and respiratory systems.

- Inspect the patient at rest and during activity (assess respiratory rate and effort)
- Check mucus membrane color and refill time
- Examine the oropharynx (most require sedation for thorough evaluation)
- Palpate the neck for masses; examine external jugular veins for distension or pulsation
- Palpate the precordium (detect thrills; assess precordial thump and point of maximal impulse)
- Auscultate the heart. Use both the bell and diaphragm (assess all four valve areas)
- Auscultate all lung regions (over both sides of the thorax)
- Palpate abdomen (assess for organomegaly, hydroperitoneum, masses)
- Palpate femoral arteries. Assess pulse pressures (strength, regularity, contour [normal, hypokinetic, hyperkinetic])
- Assess body score. Note obesity/cachexia (cachexia is common in advanced valve disease)

Auscultation Develop a systematic approach!

- Palpate left and right precordium to detect thrills (vibrations) and assess the cardiac apex beat.
- Listen to both sides of the chest at the heart base and also, at the cardiac apex. Auscultation should not be limited to these sites only.
- Valve areas at the heart base (left side) include: Pulmonic area- left 2nd to 4th ICS; Aortic area- left 4th ICS just dorsal to the pulmonic area. At the left heart apex is the is the mitral valve area usually located at the left 5th ICS at the CCJ (may be more sternal in cats or change slightly with different breeds). At the right heart apex is the tricuspid valve area- right 3rd to 5th ICS at the CCJ (cat- right 4th or 5th ICS toward the sternum).
- Apply the stethoscope bell with light pressure to collect low frequency sounds (S3 and S4, diastolic murmurs of (aortic or pulmonic regurgitation). Apply the diaphragm firmly to collect high frequency sounds (S1 and S2, systolic clicks, high pitched murmurs).
- Begin at the left apex (S1 is normally loudest). Inch forward, then dorsally. Factors that increase heart sound loudness include a thin chest, sympathetic stimulation, thyrotoxicosis, and anemia; circumstances that decreases loudness include obesity, pericardial/pleural effusions, intrathoracic masses, pneumothorax, abdominal herniation into the chest or pericardium, systolic failure.

- Simultaneously palpate the femoral arterial pulse to help time events (a peripheral pulse occurs just after the 1st heart sound). Pulse deficits suggest an arrhythmia. Vagal maneuvers might slow heart rate during tachycardia.
- Utilize selective listening. Focus on one part of the cardiac cycle at a time. Listen separately to the 1st heart sound (S1), then the 2nd heart sound (S2), the systolic interval, then the diastolic interval. Determine the intensity, quality, and splitting of each sound.
- Listen to the systolic/diastolic intervals; detect additional heart sounds/ murmurs.

Heart Sounds These are associated with the CARDIAC CYCLE which encompasses: A) contraction (systole) when the ventricles eject blood, and B) relaxation (diastole) when ventricular chambers fill.

- Ventricular systole follows closure of mitral and tricuspid valves (related to S1). When ventricular pressure increases and exceeds aortic and pulmonic pressure, aortic and pulmonic valves open, causing rapid ejection of blood. Later is systole ejection is reduced and ultimately stops.
- Ventricular diastole follows closure of aortic and pulmonic valves (related to S2). Following the early diastolic filling phase, atrial contraction occurs, contributing up to 20-25% of ventricular filling. S1 occurs at the beginning of ventricular systole. S2 occurs at the end of ventricular systole. The period between S1 and S2 represents ventricular systole; that following S2 and up until the following S1 represents ventricular diastole.
- Third (S3) and fourth (S4) heart sounds are referred to as gallop sounds.
- S3 is low frequency, heard best with the bell, and is associated with early diastolic, rapid ventricular filling. Causes include 1) high cardiac output states (anemia, hyperthyroidism, large left-to-right shunts [e.g, PDA, VSD), 2) rapid ventricular filling (severe MR, TR, AI), and 3) DCM.
- S4 is a low frequency sound associated with decreased ventricular compliance; follows atrial contraction just before S1; is called an atrial or presystolic gallop. A left-sided S4 sound is commonly detected with feline HCM, less commonly, severe systemic hypertension, AS. Isolated S4 can be related to 2nd or 3rd degree AV block.
- Ejection sounds and **clicks** are systolic high-pitched sounds heard best with the diaphragm. Mid-systolic clicks can be associated with MV prolapse.

Absent or Decreased Respiratory Sounds- causes

- Air or fluid in or around the lungs; fluid or organs occupying the thoracic cavity; Severe obesity
- Over-inflation (severe emphysema); Reduced airflow to part of lung

Adventitious Breath Sounds

- These abnormal sounds are heard over the lungs and airways.
- Sounds fine and coarse crackles (sometimes called rales); wheezes (sometimes called rhonchi).
  - ✦ Crackles – discontinuous, brief, focal or diffuse, popping sounds, most commonly during inspiration. They occur often when air opens closed air spaces (e.g. – pulmonary edema)
  - ✦ Wheezes – continuous, musical, high or low pitched, usually accentuated during expiration (e.g. – narrow airways such as with lower airway disease)

Upper Airway Sounds

- Stridor – high-pitched, wheezes like sound associated with blocked airflow in the pharynx or upper airway (e.g. – laryngeal paralysis, mass, foreign body)

Femoral Arterial Pulse Pressure

- Palpate the medial side of the thigh to locate the femoral arterial pulse pressure. Gently press down to assess the subjective magnitude of the pulse pressure. Hypokinetic pulses suggest severe aortic stenosis, shock, hypokalemia, and myocardial failure. Hypokinetic pulses can be associated with severe anemia, hypothyroidism, and sepsis.

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¿POR QUÉ MUEREN LOS GATOS? EPIDEMIOLOGÍA DE LA MUERTE CARDÍACA Y NO CARDÍACA

WHY DO CATS DIE? EPIDEMIOLOGY OF CARDIAC AND NON-CARDIAC DEATH

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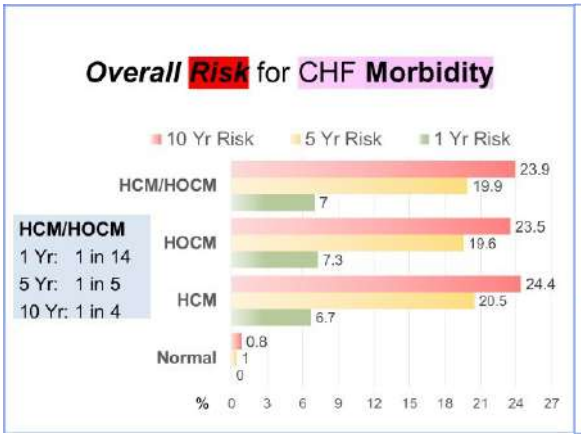
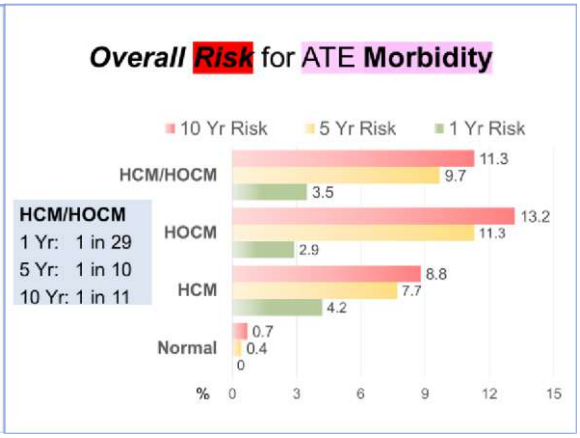
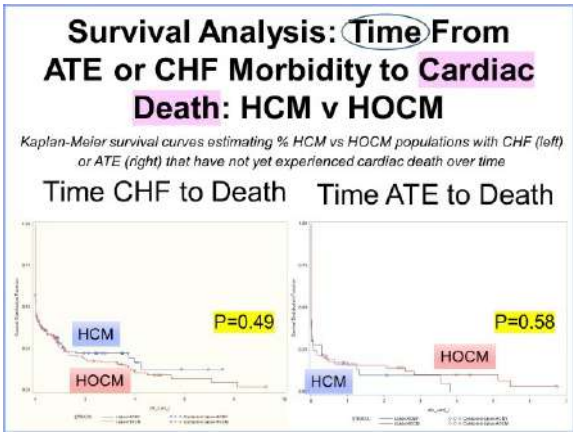




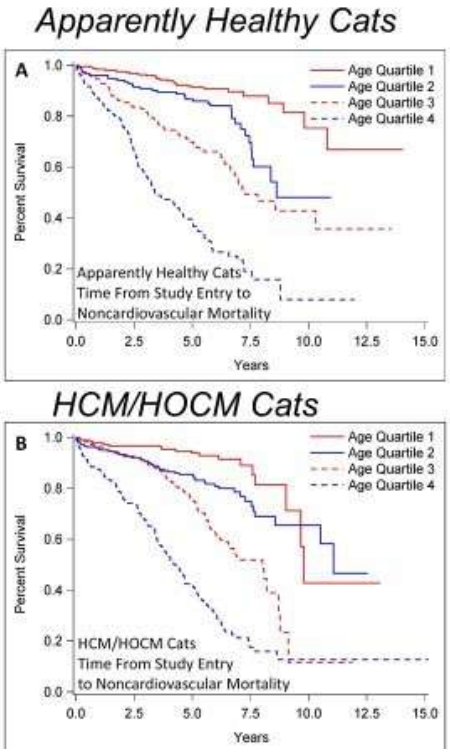


Summary

1. REVEAL helps illustrate and compare the natural history and health outcomes in preclinical HCM, HOCM, and Normal cats (n=1,730).
2. Preclinical HCM/HOCM → substantial health impact, consitant over time
3. NS difference- HCM vs HOCM
   - Cardiac survival
   - Time to morbidity
   - CHF/ATE events

Survival of 1730 Cats Stratified by Age Quartile:

Noncardiovascular Death



Fox PR, Keene BW, Lamb K, *et al.*
J Vet Intern Med. 2018 May;32(3):930-943

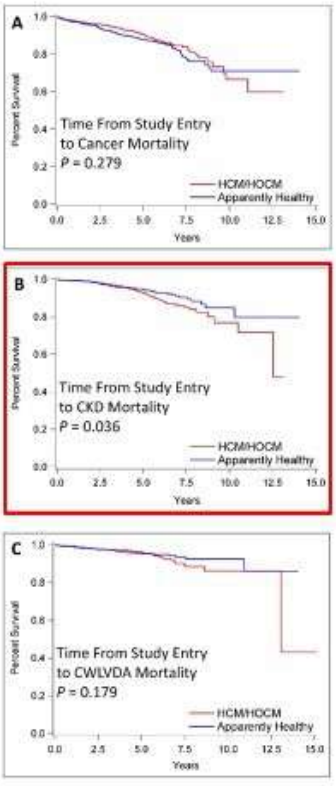
Death from Cancer, Chronic Kidney Disease, and GI Disease. Apparently Healthy Cats vs HCM/HOCM

Chronic Kidney Disease Death Risk

1 Year after examination
- 1 in 167 to 1 in 143

5 Years after exam
- 1 in to 23 to 1 in 20

10 Years after exam
- 1 in 15 to 1 in 13

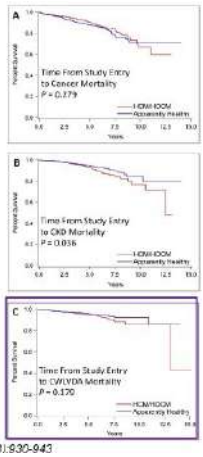


Death from Cancer, Chronic Kidney Disease, and GI Disease. Apparently Healthy Cats vs HCM/HOCM

GI Disease Death Risk

1 Year after examination
- 1 in 143

5 Years after exam
- 1 in 30 to 1 in 28



Fox PR, Keene BW, Lamb K, *et al. J Vet Intern Med. 2018 May;32(3):930-943*

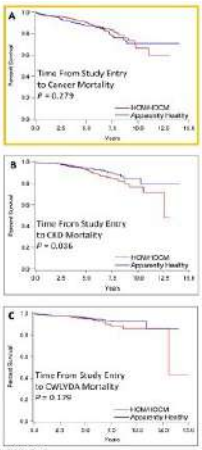
Death from Cancer, Chronic Kidney Disease, and GI Disease. Apparently Healthy Cats vs HCM/HOCM

Cancer Death Risk

1 Year after examination
- 1 in 36 to1 in 50

5 Years after exam
- 1 in 10 to 1 in 14

10 Years after exam
- 1 in 7 to 1 in 10



Fox PR, Keene BW, Lamb K, *et al. J Vet Intern Med. 2018 May;32(3):930-943*

Summary

- Cancer, CKD, and chronic GI Diseases were major noncardiovascular causes of death
- While older cats had highest noncardiovascular morbidity, substantial mortality was also recorded in the middle 2 age quartiles.
- Greatest increment of risk for death occurred at 2.5 and 5 years, compared with 1 year after study entry (eg, 2.4 and 1.9 times at 2.5 years vs 1 year, respectively), and 1.8 and 2.1 times at 5 yrs vs 2.5 years after study entry

CÓMO INTERPRETAR EL ECG Y MANEJAR ARRITMIAS CLÍNICAMENTE IMPORTANTES

HOW TO INTERPRET THE ECG AND MANAGE CLINICALLY IMPORTANT ARRHYTHMIAS

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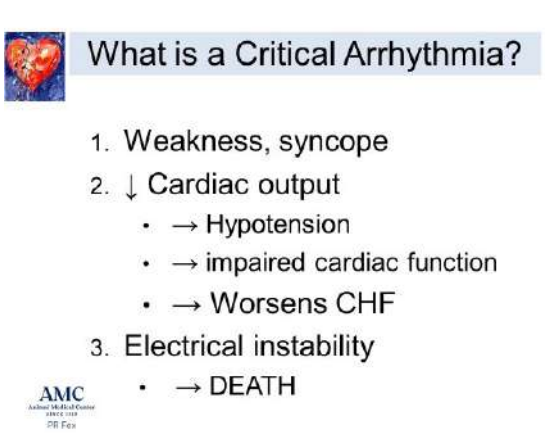

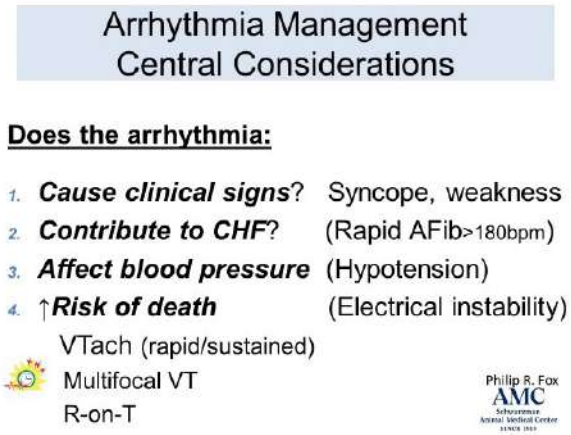

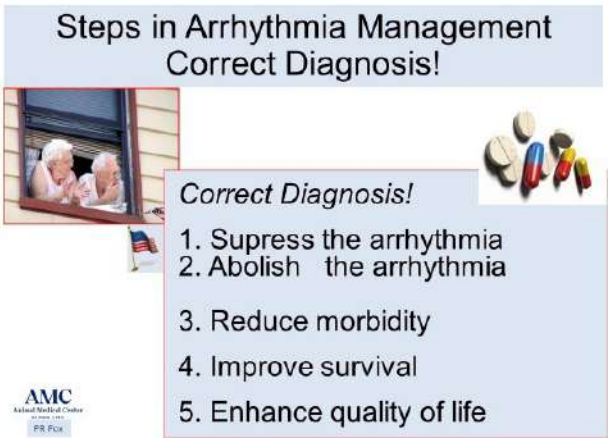

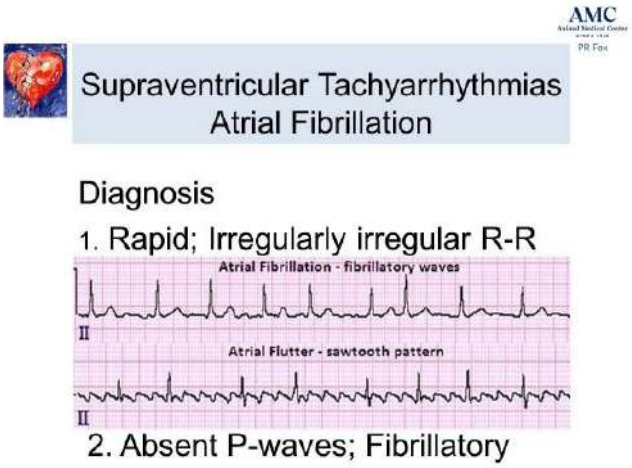

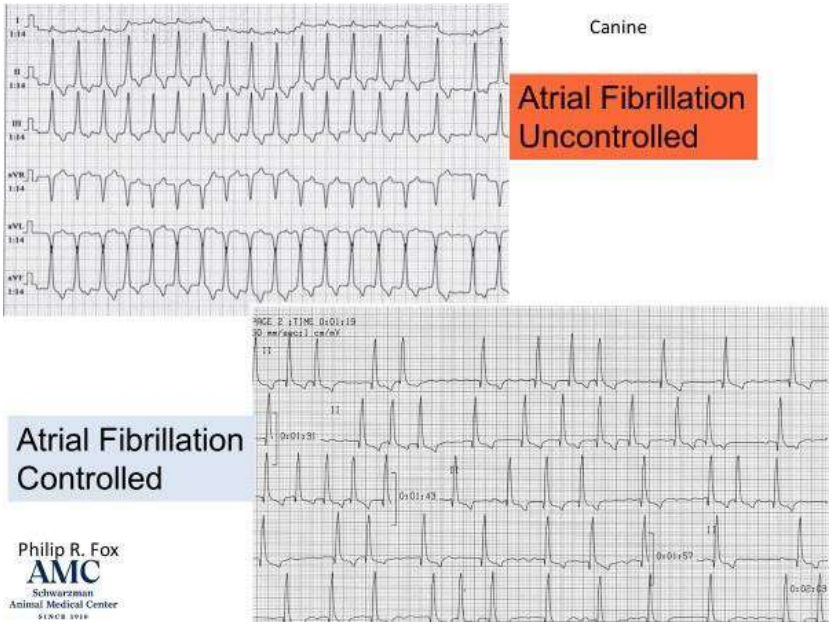

Management – Atrial fibrillation/flutter

- Optimal HR in ICU = 140-150 bpm; Home = 100-120 bpm
- **Vagal maneuvers**
  - Ocular pressure, carotid sinus massage, stimulation of the face (digital pressure or cold water)
- **Diltiazem IV** bolus: 0.1-0.25 mg/kg slowly x 2-3
  - Diltiazem CRI: 2-6 mcg/kg/min
- To transition from IV to **oral diltiazem**
  - Taper CRI Q1hr and stop in 4-6 hours
  - 5-8 mg/kg/day (divided by 3 for Q8hrs, XR available for Q12hrs dosing)
  - Start @ 3-4 mg/kg/day
- **Beta Blockers** (Atenolol): **CAUTION with CHF & DCM**
- **Digoxin Oral**: CAUTION with renal failure and ↓ K
  - 0.003-0.01 mg/kg PO Q12hrs
  - Not to exceed 0.25 mg/dog Q12hrs
- **Electrical cardioversion** – general anesthesia, patches over atria, synch

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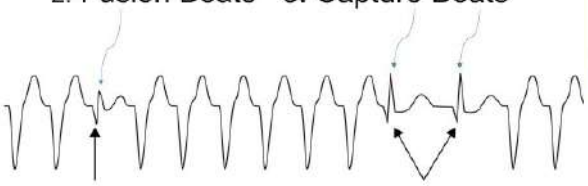
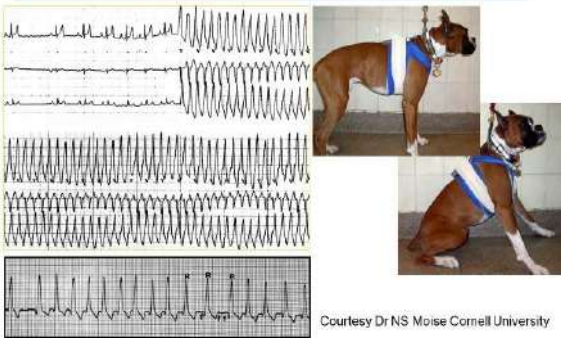
Tachyarrhythmias
Ventricular Tachycardia

Diagnosis

1. Wide complex QRS-T complexes
2. Fusion Beats 3. Capture Beats



Arrhythmia Management
Clinical Assessment



Courtesy Dr NS Moise Cornell University

Management – Ventricular Tachycardia

- Goals: to convert to normal sinus rhythm
- Drugs:
  - **IV Lidocaine**
    - Dog: 2 mg/kg IV (x4) → 50-80 mcg/kg/min
    - Cat: 0.25-0.5 mg/kg IV slowly (10-30 mcg/kg/min CRI)
  - **IV Procainamide**: 6-10 mg/kg (max total = 20 mg/kg) IV over 10 mins; CRI @ 20-40 mcg/kg/min
  - **IV Magnesium sulfate**: 0.1 mmol/kg (0.2 mEq/kg) IV over 5-15 min
  - **IV Nexterone (amiodarone)**: 2 mg/kg IV bolus over 10 mins then 0.8 mg/kg/hr x 6 hrs then 0.4 mg/kg/hr thereafter x 18hrs
  - **Beta Blocker**: Esmolol → 250-500 mcg/kg over 5 mins **CAUTION WITH CHF & DCM**
  - **Oral Sotalol**: 1.5-2 mg/kg PO Q12hrs
  - **Oral Mexiletine**: 5-8 mg/kg PO Q8hrs (+/- with sotalol)
- Uncontrollable with hemodynamic compromise: **Cardioversion starting @ 1 J/kg**
  - Shock on R wave, paddles over ventricles, anesthesia & opiates (hydromorphone or butorphanol best)
- Resolve congestive heart failure (CHF) if present
- Treat underlying (systemic) conditions
- Monitor ECG, electrolytes/renal function, blood pressure

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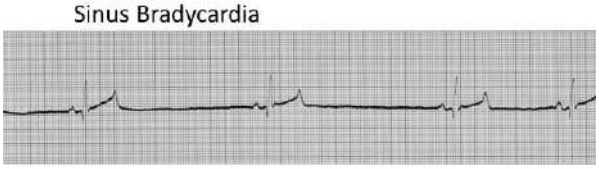
Bradyarrhythmias

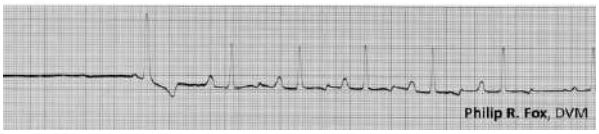
- Sinus bradycardia
- Sick sinus syndrome Sinoatrial node dysfunction
  - Brady-tachy syndrome (Sick Sinus Syndrome)
- AV block
  - 2° AVB (Mibotz I, II)
  - High Grade 2°
  - 3° AVB (Complete)

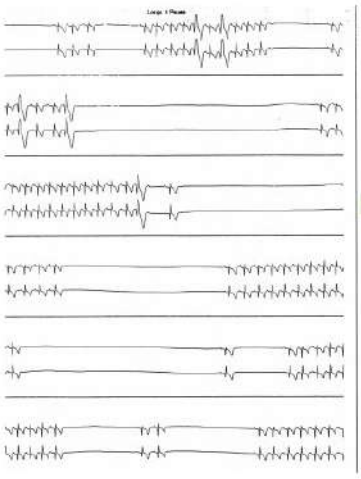
Bradycardia

Sinus Bradycardia



Sinus Pause, Sinus Arrhythmia

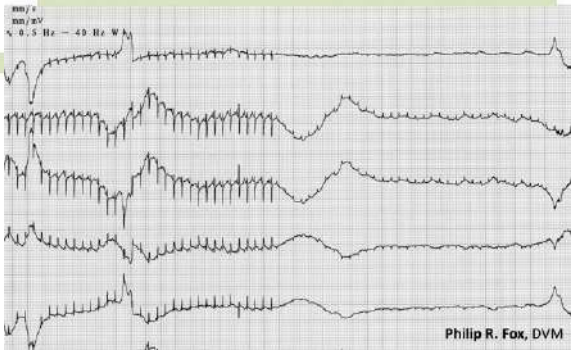




Bradycardia

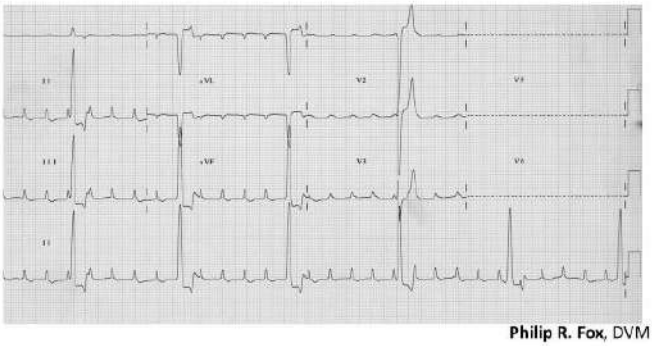
Sick Sinus Syndrome (Sinoatrail node dysfunction)

Hi Grade 2nd Degree AV Block



Philip R. Fox, DVM

Complete (3rd Degree) AV Block



Rx- PACEMAKER

MANEJO DE LA INSUFICIENCIA CARDÍACA CANINA: LO ESENCIAL MANAGEMENT OF CANINE HEART FAILURE: THE ESSENTIALS

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PURPOSE: Teach a clinical approach to diagnose, stage, treat, and follow-up care of dogs with heart disease and heart failure.

Key and Essential Points: The most common acquired heart conditions affecting dogs are chronic myxomatous valve degeneration (MMVD) and dilated cardiomyopathy (DCM). Use of history, physical examination, thoracic radiographs, and echocardiography provide the best techniques to diagnose, stage, and monitor affected canines.

EPIDEMIOLOGY

MMVD affects most dogs, especially in their mid-late life, and is the most common cause of canine cardiac morbidity (congestive heart failure- CHF) and death. The disease varies with age and breed. Dilated Cardiomyopathy (DCM) is the most common form of myocardial disease in the dog affecting predominantly large and giant breeds. Arrhythmic cardiomyopathy affects mostly the boxer and English Bulldog breeds and is characterized by ventricular arrhythmias.

CLINICAL ASSESSMENT

Optimal patient assessment includes consideration of all available diagnostic information- history, examination, ECG, radiography, ultrasound, biomarkers, clinical pathology, systolic blood pressure. This helps identify animals affected with these conditions and gauge their risk for cardiovascular morbidity.

Life threatening conditions- cardiogenic pulmonary edema, cardiogenic shock, ventricular underfilling (pericardial tamponade), hemodynamically unstable arrhythmias, and arterial thromboembolism- require immediate interventions

EVALUATING THE CRITICAL PATIENT

Assessment of the unstable patient is aided by a careful history, complete general examination, and complete data base.

Noninvasive Monitoring of Hypoxemia (Pulse Oximetry) The saturation of hemoglobin with oxygen in arterial blood (SaO2) is a useful indicator of hypoxemia. Pulse oxymetry is a noninvasive technique to allow continuous monitoring of arterial oxyhemoglobin saturation. Blood contains 4 species of hemoglobin (Hb): 1) oxyhemoglobin (HbO2), 2) reduced Hb, 3) methemoglobin (MetHb), and 4) carboxyhemoglobin (COHb). In healthy individuals, the latter 2 are in small concentration. Pulse oximetry measures functional hemoglobin saturation [SaO2= HbO2 divided by HbO2+Hb x 100], and thereby assesses *arterial oxygenation.* It does not assess *ventilation* (CO2 elimination). Hypoxemia may be a late onset sign of deteriation in some cases of respiratory failure, especially

when compensatory tachypnea has maintained normal oxygen levels. Accurate pulse oximeter readings are not always possible in every animal owing to probe placement issues, thick or pigmented skin, movement artifact, and other factors. Thus, hemoglobin saturation determined by pulse oximetry should always be evaluated in light of clinical condition. Arterial blood gas analysis should be considered whenever pulse oximetry estimation is in question.

Noninvasive Blood Pressure Monitoring Hypertension may predispose certain "target" organs to injury, particularly the eyes, kidneys, and cardiovascular and neurovascular systems. Hypotension is a common consequence of shock, dehydration, and certain drug toxicities, often suggested by systolic pressure < 90 mmHg. Systolic blood pressure >160 suggests hypertension; SBP>200 mmHg recorded on 2 occasions at least 24 hours apart indicate hypertension, unless the animal was excited. End-organ injury provides supportive evidence of hypertension.
Electrocardiography Assessment of heart rate and rhythm is essential, implies the presence of severe pericardial or pleural effusion, and can help assess certain suspected systemic and metabolic disorders (e.g., marked disturbances of potassium or calcium, ischemia, infarction). Continuous ECG monitoring, event recorders, or Holter recordings are useful to detect and monitor arrhythmias.

Radiography The radiograph 1) confirms disease suspected from the history and physical examination, 2) assesses disease severity, 3) distinguishes between cardiac and respiratory disease, 4) screens for unsuspected conditions, 5) discovers complications, and 6) and helps monitor (from repeated studies) response to therapy.
Echocardiography Diagnostic ultrasound assists cardiac examination when the heart is obscured by pleural effusion; diagnoses pericardial effusion; provides quantitative assessment of cardiac structure (valves; chamber dimensions, wall thickness); assesses systolic (contractile) and diastolic function; quantifies gradients via Doppler echocardiography; detects disturbances of blood flow; detects intracavitary masses (clots, tumors); and helps characterize congenital and acquired heart diseases.

ACUTE PULMONARY EDEMA (CONGESTIVE HEART FAILURE)

In dogs CHF results most commonly from volume overload caused by chronic degenerative valvular disease (severe mitral regurgitation) or dilated cardiomyopathy. In cats diastolic heart failure associated with hypertrophic or restrictive cardiomyopathy is the predominant underlying condition. Less common etiologies include insufficiency, left-to-right shunting (PDA, arteriovenous fistula), and high output states (anemia, thyrotoxicosis). Treatment requires aggressive measures to resolve the congestive state and improve cardiopulmonary function. Furosemide is given as initial IV bolus (24mg/kg followed q8 hr administration, or by constant rate infusion (0.5mg/kg/hour). Vasoactive drugs are added to promote venodilation and/or arterial dilation. Typically, this may include the potent vasodilator, sodium nitroprusside by CRI (2-10ug/kg/min with constant arterial blood pressure monitoring). Alternatively, hydralazine, a potent arteriolar dilator, can be given (2mg/kg PO q8-12 hrs) when pulmonary edema results from mitral regurgitation. Inotropic support using dobutamine (5-15ug/kg/min constant rate infusion) is indicated when severe myocardial failure or cardiogenic shock is present (e.g., dilated cardiomyopathy). Pimobendan is routinely given (0.25-0.3 mg/kg PPO q12 hr). Drugs to block RASS activation are included when the animal has stabilized (and when renal function is normal) . These include ACEI drugs such as enalapril, 0.5mg/gkPO q 12hrs, and spironolactone, 1-2mg/kg PO q 12 hr or 2mg/kg q 24 hr. Reversible causes of heart failure should be treated if present. Myocardial failure has very occasionally been associated with grain free diets.

Volume overload secondary to patent ductus arteriosus is correctable by surgical or occlusion techniques. Other systemic and metabolic disorders may cause or contribute to heart failure including endocarditis, myocarditis, pheochromocytoma, diabetes, and hyperthyroidism. Heartworm disease is a treatable cause of right-sided CHF.

With recurrent heart failure, upward drug titration may be necessary. In states of diuretic resistance to furosemide, torsemide can be substituted, 0.1-0.4mg/kg q 1214 hr. It is prudent to assess BUN, creatinine, electrolytes and blood pressure during chronic therapy.

CARDIOGENIC SHOCK

Myocardial failure is most commonly associated with dilated cardiomyopathy. Less frequent etiologies include chronic volume overload (eg, mitral regurgitation, left-to right shunts) or sepsis. The principal hemodynamic feature of cardiogenic shock is systemic hypotension associated with reduced ventricular pumping (ie, myocardial failure/systolic dysfunction). Pulmonary edema, systemic congestion, hypotension, and tissue hypoxia result. Acute management may require inotropes (dobutamine CRI), diuretics to reduce congestion, vasodilators such as sodium nitroprusside, pimobendan, and control of arrhythmias.

VENTRICULAR UNDERFILLING

Conditions which interfere with return of blood to the heart may result in decreased cardiac preload, compensatory neuroendocrine activation, and a clinical condition known as cardiac tamponade. This is generally associated with pericardial disease (typically neoplasia or effusions). Less common causes include space occupying atrial or ventricular masses including blood clots or tumors. Initial management requires therapeutic pericardiocentes. Avoid using drugs that decrease preload or cause vasodilation.

HEMODYNAMICALLY UNSTABLE ARRHYTHMIAS

Tachyarrhythmias may depress cardiac output, cause hemodynamic impairment or hypotension, and result in organ ischemia. Shortened diastolic filling decreases coronary blood flow, reduces myocardial oxygen supply, causes ischemia and results in more serious arrhythmias. Certain tachyarrhythmias may deteriorate by becoming electrically unstable. Hemodynamic impact of tachyarrhythmias are influenced by factors related to underlying cardiac disease and the particular type of arrhythmia (i.e., (a) loss of synchronized atrial systole, (b) altered ventricular activation sequence, (c) rapidity of ventricular rate, (d) timing of ectopic beats relative to preceding P-QRS-T complexes, (e) background vasomotor tone, (f) cardiac effects of antiarrhythmic drugs, and (g) underlying cardiac dysfunction or health). Because cardiac output = heart rate x stroke volume, sustained tachycardia may reduce cardiac output and artial blood pressure. In atrial fibrillation with rapid ventricular response, ventricular filling shortens due to loss of atrial contraction, variation in cycle length and high ventricular rate. This is worsened by concurrent myocardial dysfunction (eg, dilated cardiomyopathy) or exercise. Impulses originating in the ventricle (eg, ventricular tachycardia) alter patterns of electrical activation and reduce stroke volume. Rapid, sustained ventricular tachycardia decreases cardiac output, results in hypotension and organ ischemia. Ventricular flutter causes precipitous deterioration and all circulation ceases with ventricular fibrillation. Short paroxysms of atrial tach with normal ventricular activation may not cause clinical consequences; multifocal atrial or ventricular tachycardia are more likely to compromise hemodynamics, especially if ventricular function is abnormal. Electrical instability is increased by rapid ventricular rates and multifocal impulse origination. Additional factors include timing of the ectopic impulse (ie, the earlier the premature complex relative to the preceding T wave, the greater electrical liability). Depolarizations occurring within the preceding T wave are extremely dangerous). The underlying state of ventricular function, systemic and metabolic alterations, and concurrent drug or anesthetic agents influence electrical stability. Electrical instability is increased by rapid ventricular rates and multifocal impulse origination. Additional factors include timing of the ectopic impulse (i.e., the earlier the premature complex relative to the preceding T wave, the greater electrical liability). Depolarizations occurring within the preceding T wave are dangerous. The underlying

ventricular function, systemic and metabolic alterations, and concurrent drug or anesthetic agents influence electrical stability. Tachycardia = ventricular rate >240bpm in cats; > 180bpm in small breed dogs; > 160bpm in large breeds, and >220bpm in puppies. With supraventricular tachycardias, vagal maneuvers may occasionally convert the arrhythmia. Supraventricular arrhythmias may be treated with digitalis glycosides, calcium channel blockers, beta blockers, and other agents. Acute management of ventricular tachycardia includes treatment of the underlying cause and lidocaine. In cases with complete or high grade second degree AV block, pacemaker implantation is generally required.

Caryn Plummer

GLAUCOMA: APPROACHES TO THERAPY

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MEDICAL AND SURGICAL THERAPY FOR GLAUCOMA

As intraocular pressure has been firmly established as the primary risk factor, the establishment of a "target" or "safe" IOP for each canine eye implies an IOP reduction to levels that reduce the RGC loss from glaucoma to normal, age-related levels of RGC loss and achieving an IOP that maintains the threshold number of RGCs necessary for vision.

The primary aim in glaucoma management is the reduction of intraocular pressure, either by decreasing the production of aqueous humor or by increasing the outflow or drainage of that fluid from the eye. The objectives of therapy are to maintain vision and eliminate pain by (1) increasing aqueous outflow, (2) decreasing aqueous production, and (3) preventing or delaying glaucoma in the other eye. Primary glaucoma may be more difficult to control than secondary glaucoma because it is eventually bilateral, and blindness is a possible sequela despite therapy. I nevertheless recommend prophylactic therapy for the unaffected eye in animals afflicted with unilateral primary glaucoma. In secondary glaucoma, the inciting cause is identified and either removed or suppressed. Topical corticosteroids may be indicated to diminish inflammation when non-septic anterior uveitis is also present.

Medical therapy is the treatment of choice in animals with a history of acute primary or secondary glaucoma. Treatment should be instituted to reduce the IOP as soon as possible to alleviate pain and preserve vision. Animals presented with a history and clinical signs of chronic glaucoma should be considered for medical and surgical therapy. The iridocorneal angle gradually closes in most types of glaucoma and the initially effective treatment becomes inadequate. Surgery is the only option available when vision continues to diminish in spite of maximum medical therapy.

Medical Therapy for IOP Control

No single treatment regimen for the canine glaucomas is possible because of the many different types of glaucoma. For the secondary glaucomas, the initiating cause is identified and, if possible, either removed or suppressed.

Medical treatment of canine glaucoma is very important aspect, because surgical procedures often still require concurrent medical therapy. Medical therapy for the narrow- and closed-angle glaucomas is usually short term when employed alone, because eventually, the outflow becomes so impaired that drug-associated changes in formation and outflow are inadequate. Some clinical studies suggest that the earlier in the glaucoma process the surgery is performed, the higher the long-term success rate at controlling IOP and maintenance of vision for as long as possible. Prophylactic treatment of fellow eyes in dogs presenting with unilateral primary glaucoma appears to delay the onset of glaucoma in these eyes for several months or longer (up to 30 months).

Multiple drug therapy to decrease IOP by reducing production of aqueous humor and diminishing the resistance to aqueous humor outflow is the most effective approach. Treatment of the ocularly normotensive eye in a purebreed dog with apparently unilateral glaucoma can delay the onset of overt ocular hypertension in the second eye a median of 30 months. Betaxolol and demecarium were each effective at delaying onset of glaucoma in dogs when administered topically. Carbonic-anhydrase inhibitors reduce ciliary-body production of aqueous humor independent of diuresis. These drugs can cause metabolic acidosis, and the dosage should be carefully adjusted to minimize side effects, which include panting, nausea, and vomiting. Non-carbonic anhydrase-inhibiting diuretics do not significantly reduce IOP! Topical parasympathomimetic drugs act primarily to cause ciliary muscle contraction, increasing the outflow of aqueous humor. This action is independent of their effect on the iris sphincter muscle. Parasympathomimetics are contraindicated in glaucoma associated with anterior uveitis. They should be used with caution in glaucoma associated with anterior lens luxations. Sympathomimetic drugs reduce IOP by increasing production of aqueous humor and increasing outflow. These drugs are

most effective in reducing IOP when combined with parasympathomimetics. ß-adrenergic antagonists decrease production of aqueous humor, but the specific mechanism of action is not known. The ocular hypotensive effects are additive to those of carbonic-anhydrase inhibitors and parasympathomimetics.

Oral and intravenous hyperosmotic agents lower IOP rapidly by osmotically reducing the volume of the vitreous. They are used in the emergency treatment of acute glaucoma but are ineffective or impractical for long-term or maintenance therapy. Intravitreal glutamate levels are elevated in canine glaucoma. Glutamate is extremely toxic to the retinal ganglion cells. It overstimulates them. Glutamate excitotoxicity is mediated by intraneuronal calcium influx. Intraneuronal homeostatic imbalance induces apoptosis and cell death. The use of glutamate receptor antagonists and calcium channel blocking drugs to protect the retina and optic nerve is being studied.

Initial Medical Control	IV mannitol (1-2 g/kg IV) Adrenergics or beta-blockers (BID-TID) Prostaglandins (SID-BID) Neuroprotective drugs- memantine, amlodipine
Short-Term Control	Adrenergics or beta-blockers (BID-TID) CAIs (topical dorzolamide or brinzolamide BID-TID) Prostaglandins (SID-BID) Neuroprotective drugs- memantine, amlodipine Surgery/laser
Long-Term Control	Surgery/laser cyclophotocoagulation Supplement with medical control Adrenergics or beta-blockers (BID-TID) CAIs (topical dorsolamide or brinzolamide BID-TID) Prostaglandins (latanoprost/bimatoprost/travoprost) Neuroprotective drugs-_memantine, amlodipine

Surgical Treatment for the Glaucomas

With the narrow-angle and angle-closure glaucomas in the dog, surgical treatment is recommended early. Medical treatment usually provides a few months of effective IOP control. Unfortunately, however, surgical treatments of canine primary glaucomas have not been very successful, only lowering the IOP for several months. **Anterior chamber shunts** (i.e., gonioimplants) and **laser cyclophotocoagulation** appear to offer longer periods of successful IOP control. Targeted laser ablation with the aid of endoscopic visualization may improve our ability to decrease aqueous humor production and lower IOP for longer periods of time. If the glaucoma is secondary in origin, surgical therapy will be aimed at removing the offending cause (i.e. lens extraction with luxated or subluxated lenses). Transcleral laser procedures are less invasive, although less precise. All surgical treatment options require diligent post-operative monitoring and committed owners.

Treatment of End-Stage (Blinding) Primary Glaucomas

Salvage procedures to prevent ocular pain, to reduce the enlarged and blind globe to near-normal size, and to provide a cosmetically acceptable eye include pharmacologic destruction of the ciliary body with intravitreal injection of gentamicin or cidofivir; intrascleral or intraocular prosthesis, in which a silicone ball is placed in an eviscerated globe; and enucleation (i.e., surgical removal of the globe).

GLAUCOMA: RECOGNITION

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Glaucoma is perhaps the most frustrating ocular disease for the practicing small animal veterinarian, client and patient. It is an insidious disease that occurs in many breeds of dog (including mixed-breeds) and is associated with an increase in intraocular pressure (IOP) that is incompatible with the health of the eye. Loss of vision results in time and the acute and sustained pressure spikes that occur are quite frequently very painful for the veterinary patient. Finding efficacious ways to treat glaucoma is important because it is a leading cause of blindness in dogs and uncontrolled IOP can threaten life quality as a result of the discomfort that results.

Aqueous humor is produced in the ciliary body by active secretion and ultrafiltration of plasma. The enzyme carbonic anhydrase participates in the energy-dependent secretory phase of aqueous production. Most of the aqueous humor flows from the posterior chamber, through the pupil, to the anterior chamber, and exits at the iridocorneal angle into the intrascleral venous plexus. A small percentage of the outflow in dogs and cats (uveoscleral or nonconventional) also exits through the iris, ciliary body, choroid, and sclera. The balance between formation and drainage of aqueous humor maintains intraocular pressure (IOP) within a normal range of approximately 15 to 25 mm Hg.

Glaucoma is essentially increased IOP with associated visual deficits. In most cases in dogs and cats, glaucoma is caused by obstruction or stenosis of the aqueous humor outflow pathways. It remains a challenge to the veterinarian to detect the early subtle disturbances of glaucoma and to effectively treat this condition. Delayed or inadequate therapy can lead to irreversible blindness and a painful, cosmetically unacceptable eye.

All ocular tissues are eventually affected by the elevated IOP. The presence, individually or as a group, of a "red eye," corneal edema, mydriasis, blepharospasm, blindness, and buphthalmos can be explained by the increased IOP. If the IOP cannot be reduced, an overall increase in the size of the globe may result (buphthalmos). This change may occur more rapidly in young dogs and cats. Ruptures of the cornea's inner limiting (Descemet's) membrane may accompany the elevated corneal tension and buphthalmos to produce multiple, linear corneal striae. Persistent corneal endothelial damage can result in corneal edema. Buphthalmos causes increased tension on the lens zonules. Zonular disinsertion results in lens subluxation or luxation.

Pupillary light reflexes may be normal, slow, or absent in early glaucoma, depending on the functional status of the iris sphincter muscle, retina, and optic nerve. Acute elevation of IOP (greater than 45 mm Hg) causes paralysis of the iris sphincter and dilator muscles. Prolonged or recurrent elevations of IOP lead to degeneration of the retina and optic nerve, with excavation or cupping of the optic nerve head.

The definition of glaucoma in the dog continues to evolve and is best stated as: a group of diseases, with the major risk factor of elevated intraocular pressure, with an optic neuropathy characterized by the death of retinal ganglion cells (RGCs) and their axons. IOP-independent alterations such as excitotoxic amino acids, defects in the optic nerve head (ONH) microcirculation, and extracellular matrix (ECM) abnormalities of the ONH may also contribute to optic nerve damage in both canine and primate glaucoma.

A diagnosis of glaucoma is made based upon clinical signs and an index of suspicion for the disease. If is confirmed or supported with tonometry, or an estimate of IOP that is above the reference range of normal. Tonometry in the outpatient clinic provides only a “snapshot,” and diurnal variations in IOP occur in the dog with higher levels in the early morning and the lowest readings in the early evening, but is the easiest way to monitor the progression and response of the disease. The most common tools for tonometry in the veterinary clinic are the TonoPen (or TonoPen Vet) and the TonoVet. The TonoPen is an applanation tonometer that measures the amount of force necessary to indent a fixed surface area of the cornea. It is used after the application of a topical anesthetic agent. The TonoVet is a more recent

commercially available tool. It is a rebound tonometer that measures the rebound force and velocity that a pin returning from contacting the cornea has. It does not require topical anesthesia. Both instruments have similar accuracies and the choice of which to use is mostly based upon clinician preference, however, the rebound tonometers may be more appropriate for use in cats. IOP must be accurately measured to diagnose glaucoma. The normal canine and feline IOP is 15 to 25 mm Hg. An IOP greater than 30 mm Hg is considered pathologic and diagnostic for this condition.

The presentation of a patient with a painful, red eye requires that glaucoma be ruled out among the possible diagnoses of conjunctivitis, uveitis, or keratitis. Pain manifested as depression, anorexia, rubbing at the eye, and squinting is common. Congestion of episcleral vessels, diffuse corneal edema, a fixed and dilated pupil, and blindness will occur as the IOP increases. The onset of clinical signs in cats is often insidious, as cats are less likely to demonstrate the acute intense corneal edema and episcleral congestion exhibited in dogs. Signs of chronic glaucoma are dramatic. They include combinations of the early signs with buphthalmos, lagophthalmos, exposure keratitis, luxated lens, corneal striae, optic nerve atrophy with cupping, and retinal atrophy.

CLINICAL SIGNS

Clinical signs of the glaucomas depend on the stage of disease and, to some extent, on the type of glaucoma. The stage of glaucoma may be asymmetric in the same dog, with one eye at advanced stages of disease and the other apparently normal or at very early stages.

Stage of Glaucoma	**Clinical Signs**
Early	May be asymptomatic; slight mydriasis; mild but transient corneal edema; variable episcleral congestion; normal ONH appearance; IOPs of approximately 20 to 30 mm Hg; visual.
Mild/Moderate	Variable mydriasis, episcleral congestion, variable degrees of corneal edema/striae, slight buphthalmia, early lens subluxation, variable retinal and optic disk changes, and IOPs of 30 to 40 mm Hg; vision to visual impairment
Advanced	Persistent mydriasis, corneal edema with corneal striae, peripheral anterior synechiae and angle closure, buphthalmia, lens displacement from the patella fossa, cortical cataract formation, vitreous degeneration and syneresis, extensive retinal and optic disk degeneration, and IOPs of more than 40 to 50 mm Hg; intermittent visual impairment to total blindness.

The signs of the secondary glaucomas are like those of the primary glaucomas, but the cause for the rise in IOP, such as an anterior uveitis, an intraocular mass, or a lens luxation, is evident. The congenital glaucomas affect young puppies, usually within the first 3 to 6 months of life. Often, the first clinical sign in these animals is rapid onset of buphthalmia and inability to completely close the palpebral fissure.

CLASSIFICATION OF THE GLAUCOMAS

Canine glaucomas are divided on the basis of the possible cause, the gonioscopic appearance of the filtration angle (i.e., iridocorneal angle and ciliary cleft), and the duration or stage of the disease.

Primary glaucomas	Open/normal angle (acute/chronic) Narrow/closed angle (acute/chronic)
Secondary glaucomas	Uveitis Lens luxations

	Intumescent cataract Phakolytic/phacoclastic uveitis Hyphema Intraocular neoplasia Aphakic Malignant/ciliary block Melanocytic/Pigmentary proliferation Giant retinal tears (Schwartz-Matsuno syndrome) Anterior chamber silicone oil Postoperative ocular hypertension
Congenital glaucoma	Pectinate ligament dysplasia Goniodysgenesis

In the primary glaucomas, the IOP elevation develops without concurrent ocular diseases, is hereditary in some canine breeds, and has a bilateral potential for development. The term *goniodysgenesis* usually signals the failure of rarefaction to form pectinate ligaments at gonioscopy, though the status of deeper aqueous humor outflow tissues, especially the trabecular meshwork and trabecular ECM, is not known. A more accurate phrase than the inclusive goniodysgenesis is pectinate ligament dysplasia. Pectinate ligament dysplasia has been associated with narrow and closed angle primary glaucomas, but there are also narrow/closed primary glaucomas without pectinate ligament dysplasia. Most cases of primary glaucoma occur in purebred dogs. Siamese cats may have an inherited form of primary glaucoma.

In the secondary glaucomas, the increase in IOP is associated with some known antecedent or concurrent ocular disease that physically obstructs the aqueous outflow pathways. They tend to be unilateral conditions and are not inherited. However, some of the conditions that may initiate these forms of glaucoma, however, may be genetically determined in certain breeds, such as those with cataracts and lens luxation (i.e., dislocation). The secondary glaucomas are divided according to cause as well as by an open or narrow anterior chamber angle and ciliary cleft at gonioscopy.

Congenital glaucomas are rare in the dog and usually associated with considerable developmental abnormalities of the aqueous humor outflow pathways. The extent of the angle anomaly may affect the time of onset for the elevation of IOP: the more severe the defect, the sooner the elevation in IOP occurs.

THE SECONDARY GLAUCOMAS

The secondary glaucomas consist of diseases with increased IOP, open to closed iridocorneal angles and ciliary clefts, and detectable impairment of aqueous humor outflow, and are nearly equal to the primary types (0.9%) in prevalence in North America. Clinical management of these secondary glaucomas, however, is often more clear-cut, because the cause of the increased IOP can usually be ascertained and the prognosis for development of glaucoma in the non-affected eye is clear. Medical or surgical treatment of the secondary glaucomas is directed toward removing, if possible, the cause of the elevated IOP. Secondary glaucoma is by far more common in cats than is primary glaucoma.

Subluxated Lenses and Anterior and Posterior Lens Luxations

Lens luxations in the terrier breeds are common, and these dogs may present with either unilateral or bilateral and acute or chronic secondary glaucoma. The glaucoma may be associated with iridocyclitis from microtrauma between the unstable lens and iris, with resultant increases of aqueous humor fibrin, proteins, and inflammatory cells, which can themselves interfere with aqueous drainage, and it also may

aid in formation of preiridal fibropupillary membranes as well as anterior and posterior synechiae, which further compromise aqueous humor drainage. Anterior lens movement can mechanically impair passage of aqueous humor through the pupil, thereby causing increased posterior chamber pressure, which in turn causes anterior ballooning of the peripheral iris and reduction in the area of the iridocorneal angle outflow pathways. Such movement of the iris also contributes to formation of permanent peripheral anterior synechiae, and posterior synechia which cause a condition known as iris bombé.

The completely luxated lens can remain in the patella fossa, luxate into the anterior chamber, or move posteriorly through the torn anterior vitreal face and into the vitreous. One recent report suggests that glaucoma occurs in 73% of canine eyes with anterior lens luxations, in 43% of those with subluxations, and in 38% of those with posterior lens luxations.

Early removal of displaced lenses, particularly in Terriers, has the highest possibly of success for retention of vision and prevention of secondary glaucoma. The primary objective of lens extraction is to prevent secondary glaucoma, to diminish inflammation, or to treat the secondary glaucoma. Delayed medical or surgical treatment of eyes with displaced lenses can result in secondary glaucoma. Surgical removal of subluxated lenses, anterior luxated lenses, and the posterior luxated (i.e., intravitreal) lenses is accomplished by the extracapsular, phacoemulsification, or intracapsular techniques.

Other Forms of the Glaucoma Associated with the Lens/Aphakia

The intumescent (i.e., swollen) cataract has been associated with an acute pupillary block, phacomorphic glaucoma in the dog. The enlarged lens displaces the iris forward, thus increasing the posterior chamber pressure and causing the base of the iris to shift forward narrowing the iridocorneal angle and ciliary cleft opening.

Rupture of the lens capsule from ocular trauma and lens-induced uveitis from resorbing hypermature cataracts can cause the phacolytic form of open-angle glaucoma in the dog.

With the increased frequency of extracapsular and phacoemulsification cataract surgery and the intracapsular lensectomy for luxated lens in the dog, aphakic and pseudophakic glaucomas are becoming more frequent as well. Aphakic glaucomas probably represent multiple etiologies, with the two most frequent being occlusion of the pupil from inflammatory membranes and closure of the iridocorneal angle and ciliary cleft by formation of preiridal fibrin membranes and peripheral anterior synechia. iris bombé that bulges into the central and peripheral anterior chamber.

Malignant (or aqueous misdirection) glaucoma is a variation of pupillary block aphakic glaucoma, and it may develop after extracapsular/phacoemulsification, intracapsular cataract, or lens extraction surgery. The pupil is usually of medium size and is obstructed with inflammatory membranes, combined with either the posterior lens capsule and anterior vitreous face (with extracapsular/phacoemulsification) or the organized anterior vitreal face or membrane. Rather than remaining in the enlarged posterior chamber behind the iris bombé, the aqueous humor is either mis- or redirected into the vitreous body through a tear in its anterior face. As aqueous humor formation continues and the IOP rises, the aqueous humor is now misdirected into the vitreous body, thereby pushing the organized or formed vitreous further into the occluded pupil.

Uveitic Glaucomas

The iridocyclitides are a frequent group of intraocular diseases in the dog, and development of inflammatory glaucomas with these conditions is a serious complication. The inflammatory glaucomas may develop with either acute intense iridocyclitis, associated with pupillary occlusion and iris bombé; with obstruction of the filtration angle with inflammatory cells, fibrin, and cellular debris; or more often with chronic iridocyclitis, usually from peripheral anterior synechia but infrequently from annular posterior synechia and iris bombé. Vogt-Koyanagi- Harada syndrome, or uveodermatologic syndrome, occurs in several Arctic breeds of dogs, and a recently discovered chronic uveitis in Golden Retrievers occurs as chronic intraocular inflammations. Their serious long-term complications are cataract formation and glaucoma. Clinical signs of uveitic glaucoma are a combination of iridocyclitis and either acute or chronic glaucoma. Chronic idiopathic uveitis is the most common cause of glaucoma in cats.

Melanocytic Glaucoma

This form of glaucoma occurs primarily in the Cairn Terrier, and it may affect one or both eyes. Large aggregations of melanocytes occur within the filtration angle, episcleral and subconjunctival tissues, tapetal ocular fundus, and even in the meninges about the ONH.

Intraocular Neoplasms and Glaucoma
The most frequently occurring primary intraocular neoplasms in the dog are melanomas and adenomas/adenocarcinomas of the ciliary body and iris. Not infrequently, the presenting clinical sign of these anterior segment tumors is glaucoma, iridocyclitis, hyphema, or some combination of these. Metastatic intraocular neoplasms, which are most often adenocarcinomas, also frequently involve the iris and ciliary body. Lymphoma/lymphosarcoma may also affect the anterior uvea. Glaucomas secondary to these neoplasms usually result from direct infiltration of the filtration angle, obstruction of the angle by tumor-associated inflammatory products and peripheral anterior synechiae, or from secondary preiridal membrane formation.

Congenital Glaucomas
Extensive goniodysgenesis/trabecular maldevelopment is rare in the dog. When present, however, it may be unilateral or bilateral, and it occurs as an isolated defect or with other systemic anomalies. When present, elevations of IOP occur early in the puppy's life (usually 3–6 months of age), and the primary complaint is one of rapid and, often, dramatic globe enlargement.

Glaucoma: Approaches to Medical Therapy

Caryn E. Plummer, DVM,DACVO
Professor, Comparative Ophthalmology
University of Florida, USA

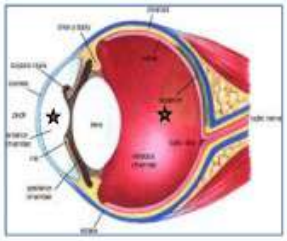
Treatment of Glaucoma

- Goals of therapy
  - Treat Primary Cause (if possible)
  - Lower IOP
    - *Decrease production of AqH*
    - *Increase outflow of AqH*
  - Neuroprotection
- Medical
  - *Topical*
  - *Systemic*
- Surgical

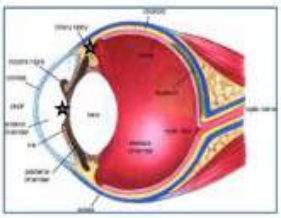
Medical Therapy

- Classes of drug
  - Hyperosmotic agents
    - *Emergency*
  - Cholinergic agonists
  - α_2 adrenergic agonists
  - β adrenergic antagonists***
  - Carbonic anhydrase inhibitors***
  - Prostaglandin analogues***
  - ROCK Inhibitors

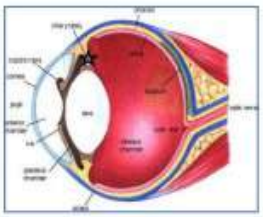
Where and how... the Hyperosmotics



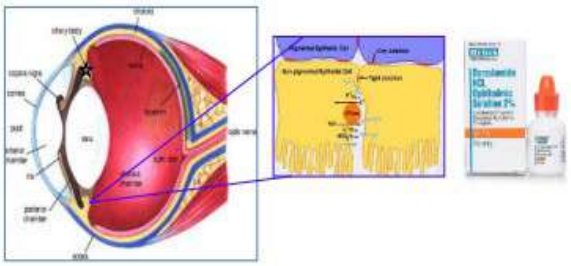
Where and how... Parasympathomimetics



Where and how... β-blockers



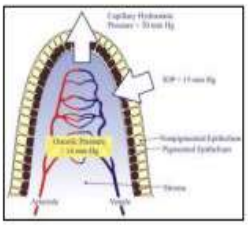
Where and how... Carbonic Anhydrase Inhibitors



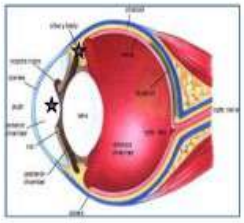
Aqueous Production

Active secretion by the non-pigmented ciliary epithelium
- Carbonic anhydrase

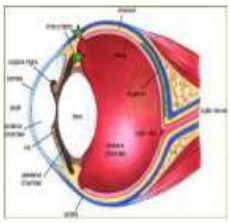
Ultrafiltration of plasma



Where and how... Prostaglandin Analogues



Where and How... Rho-Kinase (ROCK) Inhibitors



Small, statistically significant but clinically unimportant reduction in IOP in normal dogs and ADAMTS10 POAG dogs

Combo of latanoprost & netarsudil no more effective than latanoprost alone

Neuroprotection

Retinal ganglion cell death via apoptosis
- Compromised blood flow to ON
- Blockade of retrograde axoplasmal transport of neurotrophic factors that facilitate RGC survival
- Excitotoxicity
- Oxidative stress
- Inflammation
- Mitochondrial dysfunction

Neuroprotective agents
- Many topicals already in use
  - *Brimonidine, betaxolol, nipradilol, unoprostone*
- NMDA antagonists
  - *Memantine*
- Calcium Ca++ channel blockers
  - *Amlodipine*

Prophylactic Therapy

Essentially all POAG and PCAG are bilateral!

Need to treat fellow normotensive eye with topical β-blocker, prostaglandin or miotic to delay onset of ocular hypertension!

Mean time to develop glaucoma is 6 months; medical treatment can delay onset to mean of 30 months

Uveitis, Glaucoma or Both?

Chicken & Egg…?

Combination of clinical signs

Mid-range pupil

Iris bombe

Lots of corneal edema

Two disease processes to address symptomatically and simultaneously

Anterior Uveitis and Glaucoma

Topical steroids (frequency dependent upon severity and chronicity)

Topical CAI and BB (BID TID)

Avoid atropine

- Post-dilation IOP elevations
- May consider tropicamide (+/-)

Avoid prostaglandin analogues

- Pro-inflammatory
- Miotic

Feline Glaucomas

Mostly secondary

- Uveitis
- Intraocular neoplasia
- Aqueous misdirection

POAG in Siamese and Burmese

Feline Glaucoma

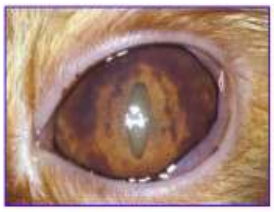
Stay visual longer than dogs

Minimal corneal edema

Be careful with beta-blockers in cats with asthma, respiratory disease

Prostaglandin analogues cause miosis in cats but minimal decrease in IOP

Aqueous misdirection may benefit from lensectomy



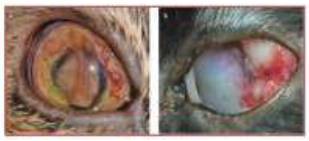
Post-Traumatic Ocular Sarcoma in the Cat

Any penetrating trauma, especially with damage to lens can incite development of **post-traumatic sarcoma**

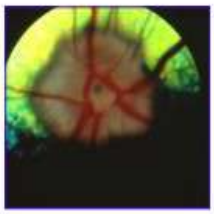
Chronic uveitis

Uveitis, glaucoma, hemorrhage, white-to-pink masses

Aggressive, non-responsive



What is a "Safe" IOP?



Once an optic nerve is damaged, the remaining axons appear to be more sensitive to further pressure insults

Lowering the IOP to less than normal levels may be most protective of the ONH

Sensitivity of the optic nerve to a particular level of IOP may change with time

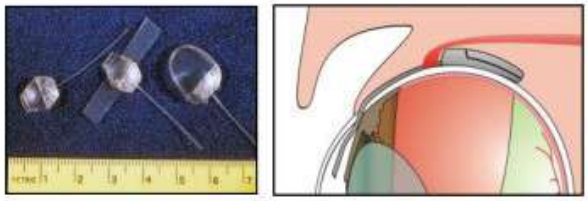
Surgical Treatment

- Gonioshunts***
- Cycloablation***
  - Cryotherapy
  - Laser photocoagulation
    - *Transscleral*
    - *Endoscopic*
- Other techniques to increase outflow
  - Iridenclesis
  - Cyclodialysis
  - Corneoscleral trephination/posterior sclerotomy + peripheral iridectomy

Pre-Operative Considerations

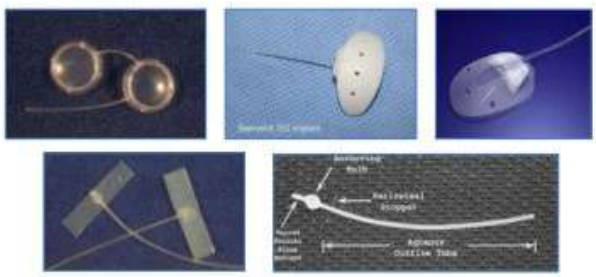
- Pre-op control of IOP
  - Should ideally be reduced to low-normal range
- Suppression of anterior segment inflammation
- Dehydration and reduction in size of the vitreous with osmotic agents

Gonioshunts

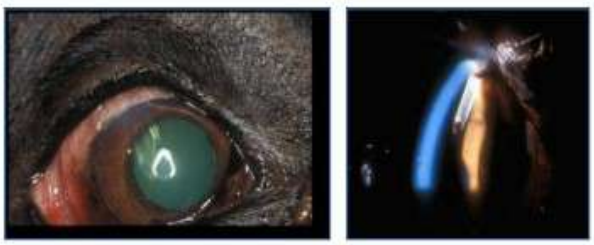


Gonioshunts

Gonioshunts



Gonioshunts



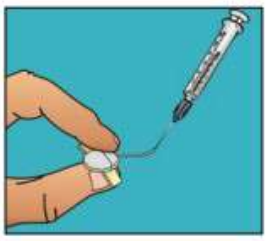
Gonioshunts

Types
- Valved
  - *Ahmed*
  - *Joseph*
- Non-valved
  - *Baerveldt*
  - *Molteno*
  - *"T" implant*

Outcomes
- Shunt alone
  - *IOP controlled for 4-15 mos*
  - *Vision lost btw 4-9 mos*
  - *68% remained visual if IOP < 20 mmHg*
- Combined with cyclodestructive procedure
  - *Vision maintained one year 41-60%*
  - *IOP control 73-76%*

Gonioshunts

Complications
- Uveitis
- Clogging of shunt
  - *Fibrin*
    - Requiring TPA
  - *Fibrosis*
- Hemorrhage
- Retinal detachment
- Infection



Anti-fibrotic Agents

May delay the development of fibrotic capsule that leads to failure of the shunt

Used at time of shunt placement or during bleb revision
- Needle revision
- Surgical excision of capsule

Mitomycin-C

5-fluorouracil

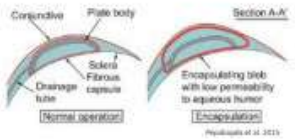
Pirfenidone

Encapsulated Bleb Formation

Common cause of drainage failure

49% incidence in humans (Christakis 2017)

Frequent sequela in dogs



Microinvasive Glaucoma Surgeries

EX-PRESS® Mini Glaucoma Shunt
- Shunt[2]

SOLX® Gold Shunt

iStent®

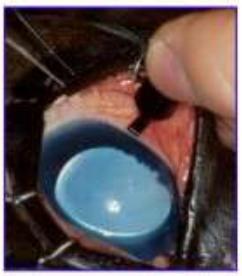
InnFocus MicroShunt®

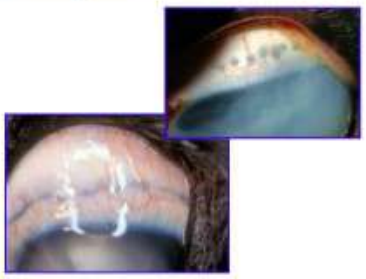
XEN® Gel Stent

Gonioscopy-assisted transluminal trabeculotomy (GATT)

Shunt[2]

Transcleral Cyclophotocoagulation





Transcleral CPC

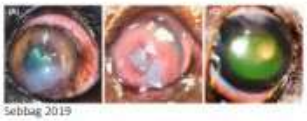
Technique
- GA
- 3-4 mm posterior to limbus
- Variety of tx protocols
  - *20 sites, 1000 mW, 5000 ms (125 J)*
  - *35 sites, 1500 mW, 1500 ms (78.7 J)*
  - *35 sites, 1200 mW, 1200 ms (50 J)*

Outcomes
- Control of IOP in 75% of cases
- Vision retained in 53%

Complications
- Uveitis
- Persistently elevated IOP
- Recurrence
- Hyphema
- Cataract
- Not as successful in lightly pigmented eyes

Transcleral Micropulse CPC

Technique
- Sedation
- 1 mm posterior to limbus
- Variety of tx protocols
  - *360°, 31.3% duty cycle, 2800 mW, 90-180 s*
  - *360°, 31.3% duty cycle, 2351 mW, 137.5 s*
  - *360°, 31.3% duty cycle, 2200 mW, 140 s*

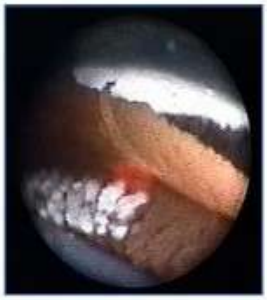


Sebbag 2019

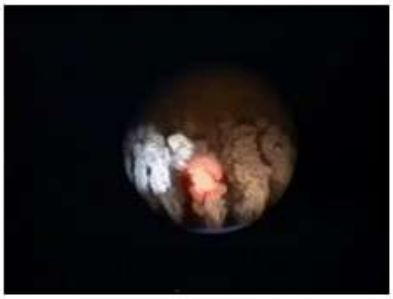
Outcomes
- Control of IOP in 92% (short term)
- Control of IOP in 42-70% (long term)
- Greater control after second treatment, 66%
- Vision retained in 42-50%

Complications
- Corneal hypoesthesia
- Refractory corneal ulcers
- KCS
- Uveitis
- Persistently elevated IOP
  - *Repeated tx*
- Recurrence
- Not as successful in lightly pigmented eyes

Endoscopic Cyclophotocoagulation



ECPC



ECPC

Technique
- GA
- Limbal incision combined with phacoemulsification or
- Pars plana approach
- Fill ciliary sulcus with viscoelastic
- 200-350 mW
- Continuous duration to effect
- 270°

Outcomes
- Maintenance of vision >60%
- Decrease in necessary medications to control IOP

Complications
- Uveitis
- Corneal ulcer
- Persistently elevated IOP
- Recurrence
- Phthsis bulbi
- Cataract in phakic eyes
- Not as successful in lightly pigmented eyes or those with many uveal cysts

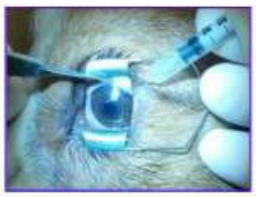
Glaucoma Emergency Therapy

If owner is motivated, refer as emergency for SURGERY!

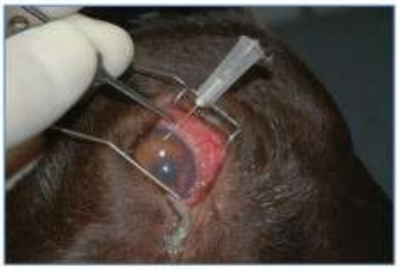
If there is **not** a mechanical obstruction of the pupil (lens lux):
- Topical prostaglandin analogue (e.g. latanoprost) q15minutes for one hour or:
- Mannitol IV 1-2g/kg
  - *Withhold water for 4 hrs*
- Start maintenance anti-glaucoma topicals
  - *CAI q8h*
  - *Beta-blocker q8-12h*

Glaucoma Emergency Therapy

If IOP does not come down with prostaglandin analogue or mannitol:
- Aqueocentesis
  - *Deep sedation, preferably GA*
  - *Prep with dilute betadine*
  - *30 ga needle*
  - *Do NOT contact iris or lens*
- Is surgery an option?



Aqueocentesis



Chronic Glaucoma Therapy

Emergency IOP lowering protocols

Does the eye have vision or the potential for vision?

Topicals
- CAI and BB BID-TID; Add prostaglandin SID-TID
- Corticosteroid anti-inflammatory SID-TID

Salvage procedure for end-stage eyes

Surgical "Salvage" Procedures

Once vision is lost, goal of therapy changes

COMFORT!!!

Enucleation

Pharmacologic ablation

(Evisceration with intraocular prosthesis)

Quality of Life

Acclimatization
- Adaptation does **not** mean the pain goes away
- Signs become chronic rather than acute
  - *Lethargy or excessive/extended periods of sleep*
  - *Inactivity or fewer interactions*

Manifestations of Ocular Pain

- Blepharospasm (squinting)
- Reflex tearing (epiphora)
- Injection/hyperemia
- Avoidance of touch
  - Headache/browache
  - Orofacial pain

Manifestations of Ocular Pain

- Conceal outward signs of pain and distress
- Changes in appetite
- Hunched appearance or posture, even in sleep
- Lethargy or excessive/extended periods of sleep
- Hiding or avoidance behavior
- Neglected grooming: unkempt, greasy, dull or spiky appearance to haircoat

Let's Anthropomorphize...

QUESTIONS FOR OWNERS

- Have you had any eye injury or inflammation in the past?
- Have you ever had an eyelash or a piece of dirt in your eye?
- Do you experience headaches, especially migraines or sinus/pressure headaches?
- Do you experience chronic pain?

Glaucoma Pain

- Headaches
- Orofacial pain
- Nausea
- Exposure of ocular surface
- Nociceptive and neuropathic
- Canine glaucoma is different from human glaucoma
  - Faster onset, more rapid course
  - Higher pressures
  - Lower response rates

Pain relief requires normalization of IOP

Opioids may modestly blunt discomfort or sedate, but do not alleviate pressure pain

Quality of Life

THINGS TO CONSIDER

- Uncertainty about level of discomfort
  - i.e. If IOP is uncontrolled and variable, it might be high without o's knowledge or recognition
- Cosmesis
  - How important really?
  - The other dogs and cats in daycare will not laugh if the pet becomes uniocular!

Happy and comfortable!

Enucleation


Pharmacological Ablation

Intravitreal gentamicin or cidofivir is toxic to ciliary body (and to the retina)

+/- Dexamethasone

Must avoid hitting lens

Does NOT address uveitis

Induction of intraocular sarcomas??

CBA

Dose
- 15-25 mg gentamicin (or)
- 500 µg cidofovir
- +/- 0.6-1.0 mg dexamethasone

Technique
- GA or sedation with topical anesthesia
- 20ga or 22ga needle inserted through sclera 6-8 mm posterior to limbus and directed toward ON
- Aspirate 0.5-1.0 mL vitreous (or aqueous if vitreous is too viscous)
- Inject drug(s)

Outcomes
- 65-86% respond with lowered IOP
- 50% success rate to second injection

Complications
- Failure to respond
- Recurrence
- Intraocular hemorrhage
- Cataract
- Corneal opacity
- Phthsis bulbi
- Neoplasia?

Phthisis Bulbi

Phthsical eyes are **not** always comfortable

Consider removal if eye comfort cannot be maintained despite normo- or hypotension

Take home

Acute glaucoma is an EMERGENCY
- Get pressure down yesterday
  - *Mannitol, Topical prostaglandin*
  - *Consider surgical intervention*

Goals of therapy
- Maintain vision as long as possible
- Keep pressures low enough for comfort

Check IOP frequently and regularly!!

Surgery early!!

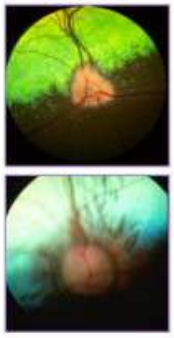
Any Questions???

Glaucoma: Recognition and Diagnosis

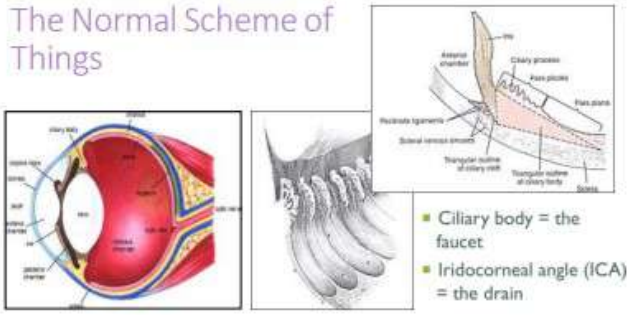
Caryn E. Plummer, DVM, DACVO
Professor, Comparative Ophthalmology
University of Florida, USA

Glaucoma

- Group of progressive optic neuropathies
- Elevation of IOP
  - Only proven treatable risk factor
  - Altered AqH outflow dynamics
- 2nd leading cause of blindness worldwide in humans
- Prevalence in dogs similar to that in humans
- Several forms
  - Primary
    - Congenital
    - Open angle
    - Narrow-closed angle
  - Secondary



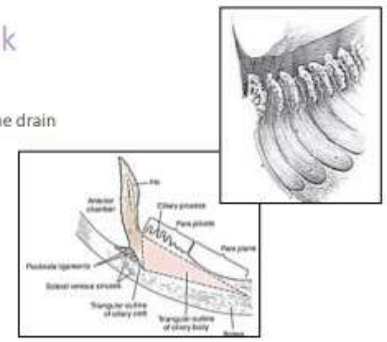
The Normal Scheme of Things



- Ciliary body = the faucet
- Iridocorneal angle (ICA) = the drain

The Kitchen Sink

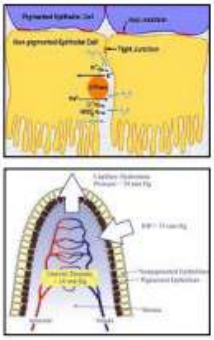
Ciliary body = the faucet
Iridocorneal angle (ICA) = the drain



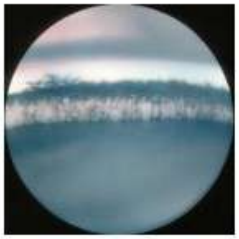
Aqueous Production

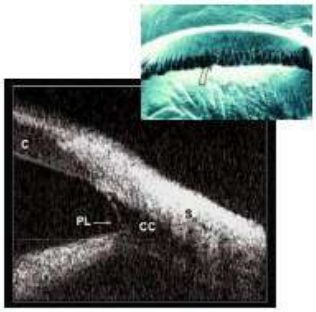
Active secretion by the non-pigmented ciliary epithelium
- Carbonic anhydrase

Ultrafiltration of plasma

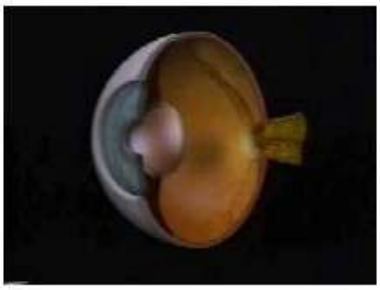


Normal ICA





Aqueous Outflow



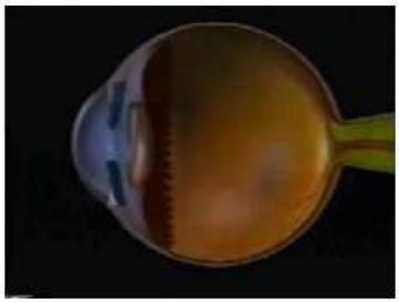
What is Glaucoma?

Group of diseases characterized by altered aqueous humor dynamics

Elevation of IOP incompatible with health of optic nerve and eye

= Clogged sink drain

What is Glaucoma?

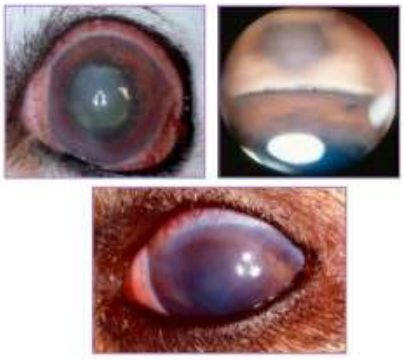


Diagnosis

Clinical signs

Index of suspicion

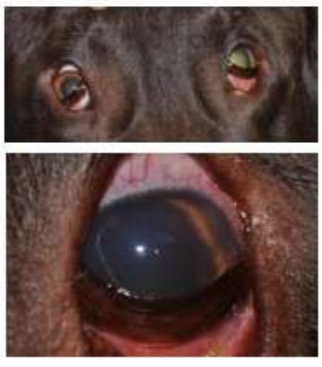
Confirmation



Clinical Signs

Acute

- Ocular pain
  - *Epiphora*
  - *Blepharospasm*
  - *"Headache"*
- Mydriasis
- Corneal edema
- Episcleral injection
- Visual loss or disturbance



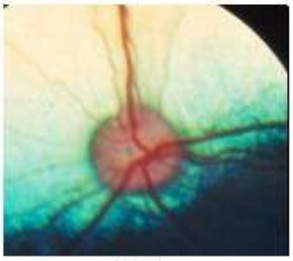
Acute Glaucoma

Clinical Signs

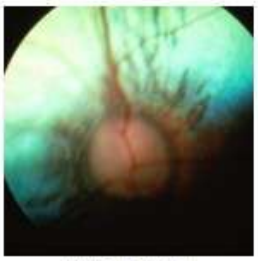
Chronic
- Permanent vision loss
  - *Optic disc cupping*
  - *Retinal degeneration*
- Buphthalmia
- Permanent corneal edema
- Striate keratopathy (Haab's striae)
- Recurrent corneal ulcerations
- Lens instability
  - *Lux/subluxation*
- Cataract formation

Chronic Glaucoma

Chronic Glaucoma

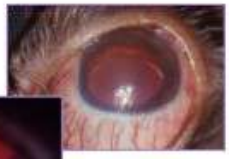


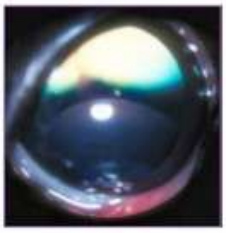
Normal

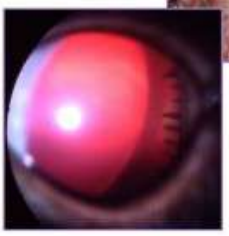


Chronic glaucoma

Which came first?







Index of Suspicion

Signalment
- Breed
- Age

History

Condition of iridocorneal angle and outflow track
- Gonioscopy
- HRUS

Provocative tests

Concurrent or antecedent disease

Types of Glaucoma

Primary
- *Congenital*
- *Open angle*
- *Closed angle*

Secondary
- *Inflammatory*
- *Mechanical*
- *Neoplastic*

Congenital Glaucoma

Usually due to developmental defect, often failure of rarefaction of drainage apparatus

May produce profound buphthalmia

May be inherited, more often a "fluke" of development or maturation

Primary Glaucoma - Breed Predisposition

American Cocker Spaniel
Bassett Hound
Chow Chow
Shar-Pei (ADAMTS17)
Boston Terrier
Wire Fox Terrier
Norwegian Elkhound (ADAMTS10 – A387T)
Siberian Husky
Cairn Terrier
Miniature Poodle
Bichon Frise
Shih Tzu

Australian Cattle Dog
Akita
Parsons Russell Terrier
English Cocker Spaniel
Lhasa Apso
Bouvier des Flanders
Pekingese
Beagle (ADAMTS10 / G661R)
Brittany Spaniel
Saint Bernard
English Springer Spaniel
Dalmatian
PBGV (ADAMTS17)

Primary Open Angle Glaucoma

Inherited condition

Most common form in people

Insidious onset

Progressive (despite appropriate therapy), blinding, painful

Initially ICA & scleral cleft are open

Open Angle Glaucoma: History

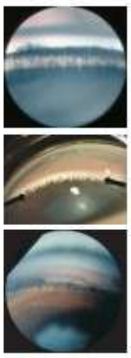
Insidious onset

Maintain vision longer

Late recognition

Bilateral at presentation

Age (mos)	Glaucoma group	Angle width	Other findings
0-6	Pre-glaucoma	Normal	No angle anomalies
7-12	Early glaucoma	Normal	
13-18	Glaucoma	Normal	
19-24	Glaucoma	Normal to narrow	Narrow areas are focal
25-30	Glaucoma to advanced glaucoma	Normal to narrow	
31-36	Advanced glaucoma	Narrow	
36+	Advanced glaucoma	Narrow to closed	Focal anterior synechia



Narrow-Closed Angle Glaucoma: History

Most common form in dogs

Characterized by abrupt increases in IOP which are initially transient

Eventually elevation becomes persistent

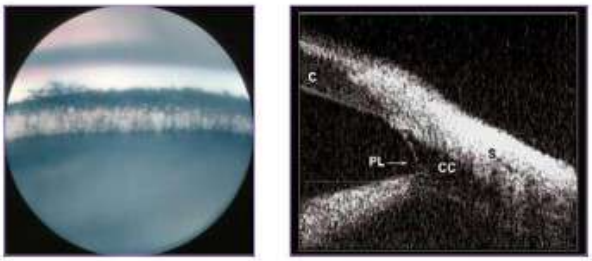
Clinical signs evident unilaterally (initially)

Stages
- Latent
- Intermittent (subacute)
- Congestive (acute)
- Post-congestive
- Chronic

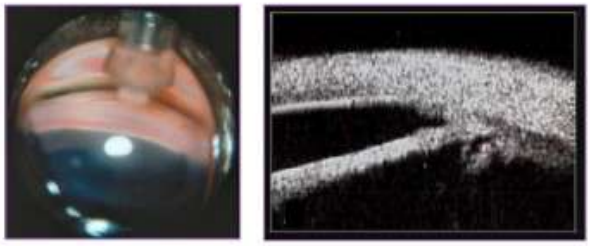
Gonioscopy

Gonioscopy

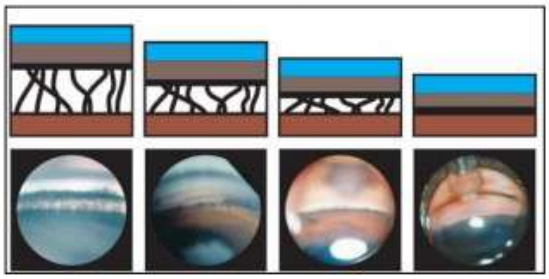
Normal ICA



Narrow/Closed Angle



Stages of Angle Closure

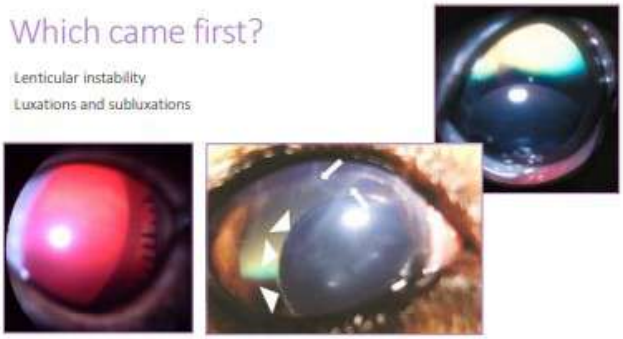


Provocative Testing

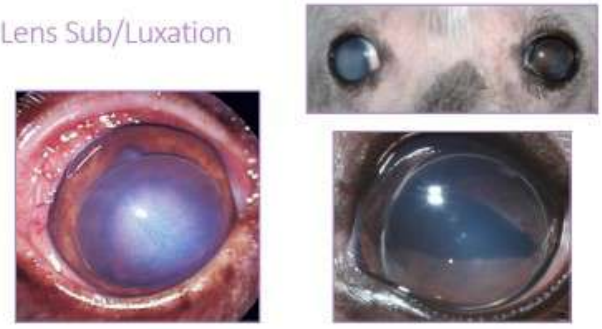
Mydriatic provocation: IOP before and following pharmacologic mydriasis
Corticosteroid provocation
Water provocation

Which came first?

Lenticular instability
Luxations and subluxations



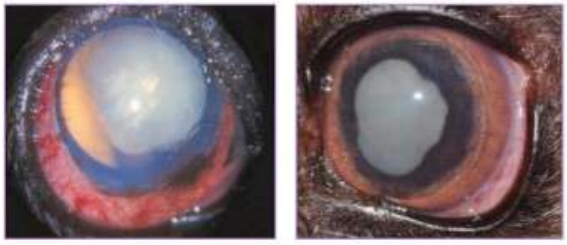
Lens Sub/Luxation



Lens Luxation – Breed Predisposition

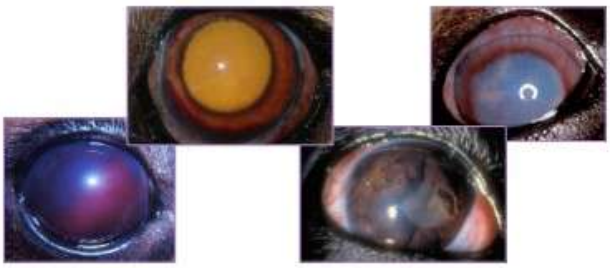
Parsons Russell Terrier	Sealyham Terrier
Fox Terriers	Border Collie
West Highland White Terrier	Chinese Crested Dog
Lakeland Terrier	Chihuahua
Cairn Terrier	Poodles
Manchester Terrier	Welsh Terrier
Miniature Bull Terrier	Miniature Schnauzer
Tibetan Terrier	Spaniels
Norfolk Terrier	Boston Terrier
Norwich Terrier	Corgis
Scottish Terrier	PBGV
Skye Terrier	...

Secondary Glaucoma: Lens-Induced



Secondary Glaucoma: Post-Operative

Secondary Glaucoma: Uveitis



Secondary Glaucoma: Pigmentary Uveitis

Secondary Glaucoma: Melanocytic

Secondary Glaucoma: Intraocular Neoplasia

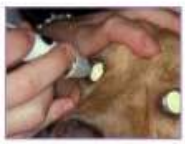
Confirmation

Tonometry
Histopathology

Tonometry

Via applanation or rebound
- TonoPen or TonoVet

Normal canine & feline IOP = 15–25 mmHg
- Ideal target = low teens
- May vary with eye/orbit conformation
  - *Brachycephalic animals tend to run higher*
- May vary with instrument used
  - *Consistently use same instrument for same patient*



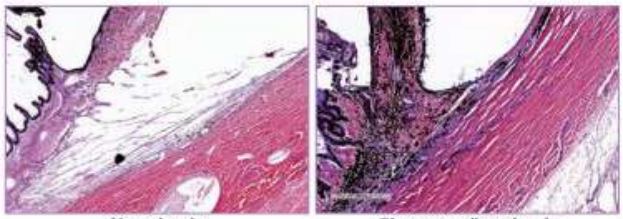
Tonometers

Digital

Applanation
- Schiotz
- Tonopen

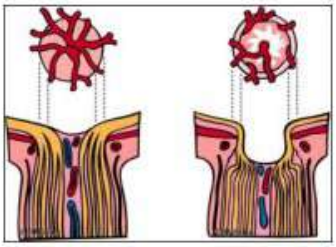
Rebound
- TonoVet
- TonoVet Plus

Iridocorneal Angle



Normal angle | Glaucoma, collapsed angle

Optic Nerve Degeneration



Recognizing Glaucoma in the Cat

- Mostly secondary
  - Uveitis
  - Intraocular neoplasia
- Primary does occur
  - Mostly POAG
    - *Siamese, Burmese, Persian & European Shorthair*
  - Pectinate Ligament Dysplasia
    - *Siamese*
  - Narrow Angle
    - *Burmese*

Recognizing Glaucoma in the Cat

Recognizing Glaucoma in the Cat

Aqueous misdirection
AKA malignant glaucoma

Feline Glaucoma

Mydriasis!

Less prominent buphthalmos
Little episcleral injection
Less edema
Elongated ciliary processes
Overt manifestations of pain absent

Take home

Glaucoma is a painful and potentially blinding disease
Important to recognize clinical signs and risk factors
Early diagnosis and treatment can delay vision loss and improve comfort

Any Questions???

OCULAR PHARMACOLOGY:
CONSIDERATIONS FOR DRUG CHOICES

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PROFESSOR, COMPARATIVE OPHTHALMOLOGY, COLLEGE OF VETERINARY MEDICINE, UNIVERSITY OF FLORIDA

IMPORTANT CONSIDERATIONS

- Obstacles to drug delivery
- Routes and target tissues
- Formulations
- Delivery
- Therapeutic goals

OBSTACLES TO DRUG DELIVERY

- Continuous tear flow
- Epithelial tissue with poor permeability
- Limited vascular supply to cornea
- Blood ocular barriers
  - Blood-aqueous barrier
  - Blood-retinal barrier
  - Blood-brain barrier
- Lack of patient cooperation
- Poor owner compliance

TEAR FLUID

- Tear concentration half-life of 3 to 6 min
- Washout times shortened by increased tear production or increased drainage/blinking rate
- Spillover absorbed by mucous membranes (nasolacrimal duct, nasal passages, oropharynx and digestive tract)
  - May cause systemic side effects

BARRIERS TO PENETRATION

- Combination of physical obstacles and active removal mechanisms
- Blood-ocular barriers are critical for the maintenance of the delicate homeostasis of the ocular transparent media, but act as a major obstacle to the access of topical and systemic medications to intraocular target tissues

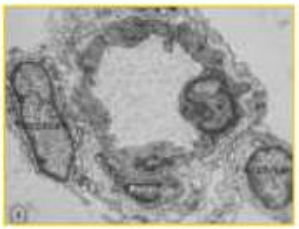
BARRIERS TO PENETRATION

- Globe is protected physically by tough layers of sclera and cornea
  - Lipophilic corneal epithelium
  - Hydrophilic corneal stroma
- Blood ocular barriers
  - Blood aqueous barrier
  - Blood retinal barrier
  - Blood brain barrier
  - These semi permeable barriers prevent large molecules from entering the eye and this maintains a clear ocular media

BARRIERS TO DRUG DELIVERY

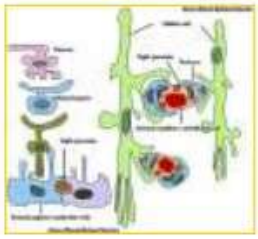
BLOOD-AQUEOUS BARRIER

- Tight junctions between cells of the ciliary epithelium and vascular endothelium (iris and CB) and posterior iris epithelium



BLOOD-RETINAL BARRIER

- Retinal pigment epithelium
- Retinal vascular endothelium

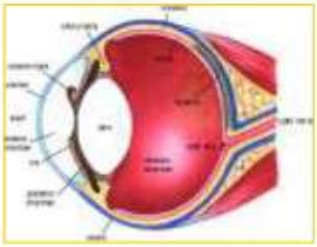


BLOOD-BRAIN BARRIER

- Astrocyte mediated transport
- Tight junctions of endothelial cells

ROUTES OF ADMINISTRATION

- Topical
- Subconjunctival/Sub-tenon
- Intraocular
  - Intracameral
  - Intravitreal
  - Suprachoroidal
- Retrobulbar
- Systemic
  - Parenteral
  - Per os



ROUTES AND TARGETS

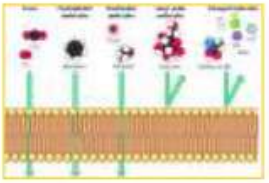
Topical	Conjunctiva, TE, NLD, cornea, anterior uvea, lens
Subconjunctival	Conjunctiva, TE, anterior segment, sclera
Intracameral	Anterior and posterior segments
Retrobulbar	Posterior segment, optic nerve, orbit
Systemic	Lids, uvea, vitreous and retina, optic nerve, orbit

TOPICAL FORMULATIONS

- Solution
- Suspension
- Ointment
- Inserts
- Drug impregnated collagen shields, implants
- Soft contact lens
- Cornea is main route of entry; some drug diffuses through conjunctiva and sclera but most eliminated by choroidal circulation

FACTORS INFLUENCING PENETRATION

- Drug concentration and solubility
- Viscosity
- Lipid solubility
- Surfactants
- pH
- Drug tonicity
- Molecular size and weight



SOLUTIONS & SUSPENSIONS

- Solutions
  - Drug dissolved in solute
- Suspensions
  - Drug suspended in solute
- Advantages
  - Less vision disturbance
  - Less toxic to inside of eye
  - Easier to apply
- Disadvantages
  - Short contact time
  - Dilution effects
  - Must mix suspensions well
  - Increased systemic absorption

OINTMENTS

- Drug suspended in oily base
- Advantages
  - Longer contact time
  - Not diluted as easily
  - Lubrication
  - Less expensive
- Disadvantages
  - Imprecise dosage
  - Increase ocular discharge
  - Visual disturbance
  - More difficult to apply
  - Greater incidence of contact dermatitis
  - May delay epithelial wound healing

CONTACT LENS

- Superficial corneal lesions
- Increase drug contact time
- Scaffold for migrating epithelial cells
- May be drug impregnated

ENHANCEMENT OF TOPICAL PENETRATION

- Pro-drug that is enzymatically activated to active drug in cornea or after penetration
- Co-administer amphiphilic or chelating agent to enhance penetration
- Modify integrity of epithelium by physical techniques (i.e. iontophoresis)
- Enhanced viscosity
- Nanocarriers
- Sustained release

TOPICALS: PRACTICAL CONSIDERATIONS

- Wait 5 minutes between each topical medication
- Protect globe, lids from self-trauma
  - E-collar
  - Doggles
  - Hard-cup hood, fly mask
  - Mittens
- One drop (50 µL), 0.1-0.2 mL via SPL, or 5 mm ribbon is sufficient amount
- Lacrimal lake can accommodate 20-30 µL

SUBPALPEBRAL LAVAGE

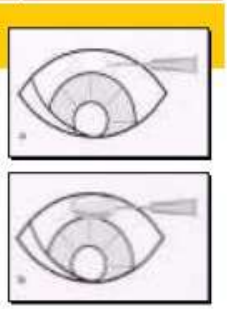
- Overcome patient resistance
- Ease administration
- Increase frequency
- Increase safety
- Increase efficacy
  - Ensure delivery

OVERCOMING BARRIERS TO DELIVERY AND LOCALIZATION

- Direct injection
  - Microneedles
- Sustained release implants
  - Suprachoroidal
  - Intravitreal
  - Anterior chamber
- Iontophoresis
- Photodynamic therapy

SUBCONJUNCTIVAL ADMINISTRATION

- Medication injected under conjunctiva
  - Usually requires sedation
  - Topical anesthetic
  - Maximum volume: 0.5 cc dog, 1 cc horse



SUBCONJUNCTIVAL INJECTIONS

- Advantages
  - Long duration (depends upon the drug and vehicle, 2-48 hours)
  - High anterior chamber concentration
  - Deliver drugs which cannot penetrate cornea due to large size
- Disadvantages
  - Limited number injections
  - Scar tissue formation
  - Can't remove once given!

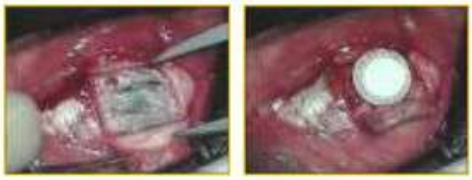
SUBCONJUNCTIVAL INJECTIONS

SUBCONJUNCTIVAL IMPLANTS

- Surgically implanted silicone matrix impregnated with cyclosporine for ocular surface disease
  - Dry eye (KCS)
  - Immune-mediated keratitis

SUPRACHOROIDAL IMPLANTS

- Cyclosporine
- Chronic, recurrent uveitis



MICRONEEDLES

- Set length (500-750 µL)
- Corneal stroma
- Suprachoroidal space

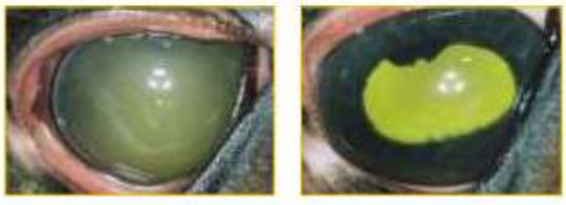
INTRACAMERAL ADMINISTRATION

- Indicated for intraocular infections, glaucoma (chemical ablation), fibrinolytic therapy only
- Inject drug directly into AC or vitreal chamber
- High concentrations achieved but for short periods due to high aqueous humor turnover
  - AqH turnover: 5 µL/min (dogs)
- Requires sterile technique and topical anesthesia, often general anesthesia

INTRACAMERAL ADMINISTRATION

- Advantages
  - High drug concentration achieved
  - Target tissue directly
  - Bypass barriers to administration
- Disadvantages
  - Many potential risks
    - Hyphema
    - Introduction of infection
    - Cataract
    - Retinal degeneration
    - Beware of contacting the lens!!

INTRACAMERAL ADMINISTRATION



Pre- and Post-Intracameral TPA – fibrinolysis

INTRAOCULAR IMPLANTS

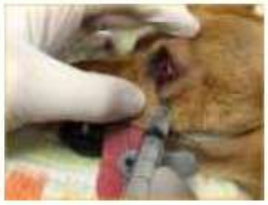
- Intravitreal devices
  - Steroids
    - Fluocinolone
    - Dexamethasone
  - Anti-glaucoma
    - Latanaprost
  - Anti-VEGF
  - Immunomodulators

RETROBULBAR ADMINISTRATION

- Most common indication is for regional anesthesia
  - Prior to enucleation
  - To facilitate ocular paralysis for ophthalmic surgical procedures


RETROBULBAR ANESTHESIA

- Several different approaches
  - Follow orbital rim
  - Four point block
  - Via supraorbital fossa
  - Peterson block
- Lidocaine, bupivicaine, mepivicaine
- Be careful!!
  - Vagal response
  - Hemorrhage
  - Damage to optic nerve
  - Introduction of infectious agents
  - Calculate toxic dose

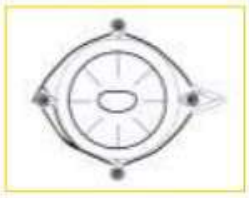


RETROBULBAR ANESTHESIA

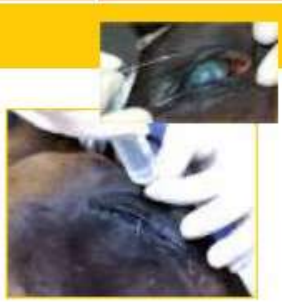
- Ventrolateral Approach
- 1.5" needle, bent to approximate curve of orbital rim
- Lower lid, 1/3 from lateral canthus
- Aspirate before injecting

FOUR POINT BLOCK

- 22ga 1.5 - 3.5 inch spinal needle
- Bent to a curve approximately that of the orbital wall
- Insert needle adjacent to the globe at the 12-, 3-, 6-, and 9-o'clock positions and inject at each site.



FOUR POINT BLOCK

SYSTEMIC ADMINISTRATION

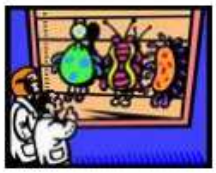
- Exposes entire body to drugs
- Indicated if tissue cannot be accessed by topicals
  - Vitreous, retina, posterior uvea, orbit, lids
- Penetration limited by blood-ocular barriers and avascular tissue

FACTORS INFLUENCING SYSTEMIC ABSORPTION

- Lipid solubility
- Protein binding
- Ocular inflammation

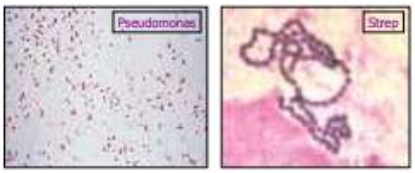
WHICH ANTIBIOTIC TO CHOOSE?

- Culture and susceptibility
- Initial therapy is empiric
- May need to be modified after C & S



ANTIBIOTICS

- Most commonly isolated bacterial agents from corneal wounds
  - *Pseudomonas*
  - *Streptococcus*
  - *Staphylococcus*



ANTIBIOTICS

- Classes
  - Penicillins
  - Cephalosporins
  - Aminoglycosides
  - Tetracyclines*
  - Chloramphenicol*
  - Polypeptides
  - Fluoroquinolones
  - Macrolides*
  - Sulfonamides*
  - Fusidic acid

* = static

ANTIBIOTICS

- Most antibiotics are toxic to corneal epithelium to varying degrees
- Judicious use to prevent development of resistance
- Frequency depends on presence or absence of infection

ANTIBIOTICS

- Prophylatic use vs. directed therapy
- Simple, non-infected ulcers should be treated with broad-spectrum antibiotics
  - 3-4 times a day
  - Prevent infection
- Infected ulcers should be treated very frequently to sterilize the wound
  - q1-4h
  - Taper once infection is controlled
  - In combination with anti-collagenase therapy
- Duration of tx depends on rate of resolution
  - Until fluorescein is no longer retained
  - Resolution of cellular infiltrate
  - Uveitis resolved

ANTI-FUNGALS

- Directed therapy vs. prophylactic therapy
- Geography
- Frequency q2-6h
- Extended length of therapy

ANTI-FUNGALS

- Polyenes
  - Natamycin, amphotericin B, nystatin
- Azoles
  - Flu, itra, micon, vori, luliconazole
- Echinocandins
  - Caspofungin
- Silver sulfadiazine

ANTI-VIRALS

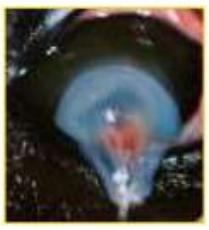
- Trifluridine®
- Idoxuridine
- Cidofovir
- Interferon
- Famcyclovir
  - 90 mg/kg BID-TID PO
- Lysine
  - 250-500 mg/cat BID PO

ANTI-VIRALS

- Do not taper
- Continue until clinical signs resolve, then 1-2 weeks, then discontinue
- Most compounds act on viral replication cycle and are virostatic – therefore tx frequently 4-6x/d
- Cidofovir 0.5% BID
- Unable to eradicate latent infections
  - Recurrence possible

ANTI-COLLAGENASE

- Anti-protease activity
- Growth factors
- Decrease enzymatic breakdown of corneal architecture
- Sources of destructive enzymes
  - Bacteria
  - Fungi
  - Host PMNs
  - Host epithelial cells
  - Host fibroblasts



ANTI-COLLAGENASE

- May need more than one anti-collagenase agent!
- Duration
  - Until melting has stopped and ulcer has re-epithelialized
- Serum or plasma
  - Refrigerate
  - Good for ~ 8 days
- EDTA (0.17%)
  - Make by mixing sterile water in lavender tube to fill line
- N-acetylcysteine (5%)
  - 5 mL 20% NAC in 15 mL artificial tears

ANTI-COLLAGENASE

- Topical 0.025% - 0.1% doxycycline
- Systemic doxycycline or minocycline
- Ilomostat (Galardin)
- Combinations thereof

ANTI-INFLAMMATORY AGENTS

- Corticosteroids
  - Better efficacy
  - Topical
    - Prednisolone acetate
    - Dexamethasone
    - Contraindicated with corneal ulcers
  - Systemic
    - Use extreme caution with infections
- Non-steroidals
  - "Relatively" safe
  - Topical
    - Diclofenac, Flurbiprofen, Suprofen, Indomethacin, Bromfenac
    - Clinical use expanding
  - Systemic
    - Carprofen, Meloxicam, Robenacoxib, Firocoxib, Flunixin, Phenylbutazone

GLUCOCORTICOIDS

- Suppress cyclooxygenase and lipoxygenase pathways
- Decrease vasodilation and permeability
  - Inhibit leakage of protein/cells into anterior chamber
- Reduce leukocyte recruitment
- Inhibit fibroblasts, neovascularization

CORTICOSTEROID POTENCY (RANK)

- Fluorometholone
- Betamethasone
- Dexamethasone
- Methylprednisolone
- Prednisolone
- Triamcinolone
- Hydrocortisone

(Penetration: acetate > alcohol > phosphate)

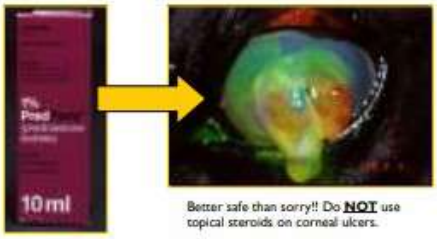
GLUCOCORTICOIDS

- Adnexal diseases
  - Topical 2.5% hydrocortisone, 0.25-0.5% prednisolone or 0.1% dexamethasone
  - Subconjunctival
- Cornea & uveal diseases
  - Topical 1% prednisolone or 0.1% dexamethasone or 0.5% lotoprednol
  - Subconjunctival (cornea)
  - Suprachoroidal (uveal)
  - Intracameral
- Posterior segment & orbital diseases
  - Systemic prednisolone or dexamethasone
  - Intracameral
  - NSAIDS often preferable

DISADVANTAGES AND SIDE EFFECTS OF GLUCOCORTICOIDS

- Retard epithelization
- Decrease corneal wound/incision strength
- Potentiate microbial activities
- Cataract formation
- Calcific keratopathy
- Systemic: diabetes, gastritis, weight gain, polydipsia/polyuria, skin thinning, hypertension, inappropriate calcium deposition, insomnia, depression/mood disorders, appetite changes, osteoporosis

GLUCOCORTICOIDS



Better safe than sorry!! Do **NOT** use topical steroids on corneal ulcers.

STEROID TREATMENT PARADIGM

- Induction: strongest steroid tolerated
- Tapering: only when there are no signs of inflammation
- Maintenance therapy: minimum effective strength and dose
- Local therapy: whenever possible (preferred to systemic)
- Systemic therapy: steroid sparing whenever possible
- Individualize therapy
- Pre-operative prophylaxis

NON-STEROIDAL ANTI-INFLAMMATORIES (NSAIDS)

- Prevent synthesis of prostaglandins
  - COX inhibition
- Prevent/lessen breakdown of blood aqueous barrier
  - Less AqH flare & fibrin
- Maintain, facilitates mydriasis (esp during IO surgery)
- Stop/slow corneal vascularization
- Helps with atropine-resistant mydriasis

DISADVANTAGES AND SIDE EFFECTS OF NSAIDS

- Topical side effects
  - Impaired wound healing
  - Inhibits corneal vascularization
  - Potentiates keratomalacia
- Systemic side effects
  - Renal toxicity
  - GI ulcerations
  - Gastritis/colitis
  - Liver toxicity
  - Inhibits corneal vascularization

SYNERGY: CORTICOSTEROIDS & NSAIDS

- Steroids for chronic pain, anterior segment inflammation and ocular surface inflammation
- NSAIDs for immediate pain relief, anterior segment inflammation
- Greater degree of control than with either alone

IMMUNOMODULATORS

- Topicals: cyclosporine, tacrolimus, sirolimus, pimecrolimus
  - Lacrimostimulant (Quantity & Quality)
  - Anti-inflammatory
  - Immunosuppressive
    - Inhibits T-cell activation and thus cytokine production
    - Used for immune-mediated diseases
      - KCS
      - Immune-mediated keratitis, keratoconjunctivitis
      - Uveitis
- Systemic: cyclosporine, azathioprine, leflunomide, methotrexate, cyclophosphamide, etc…

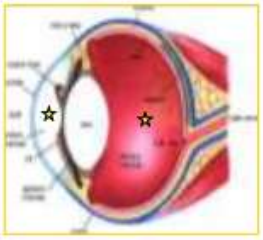
GLAUCOMA THERAPY

- Goals of therapy
  - Lower IOP
    - Decrease AqH production
    - Increase AqH outflow
  - Decrease inflammation (if present)
    - Systemic NSAIDs
    - +/- Topical steroids
  - Neuroprotection

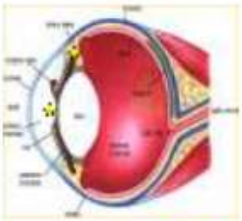
MEDICAL THERAPY

- Classes of drug
  - Hyperosmotic agents
    - Emergency
  - Cholinergic agonists
  - α_2 adrenergic agonists
  - β adrenergic antagonists***
  - Carbonic anhydrase inhibitors***
  - Prostaglandin analogues***
  - ROCK Inhibitors

WHERE AND HOW… THE HYPEROSMOTICS



WHERE AND HOW… PARASYMPATHOMIMETICS



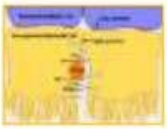
Just say "NO!"

BETA-BLOCKERS

- β-adrenergic antagonist
- Selective or non-selective
- Small IOPs decrease
- Prophylaxis for fellow eye
- Many available
  - Timolol
  - Betaxolol
- Side effects
  - Miosis
  - Bradycardia

CARBONIC ANHYDRASE INHIBITORS

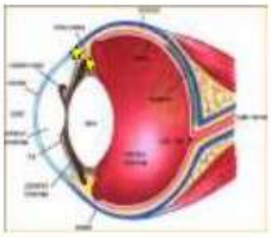
- At therapeutic levels: +/- 30% decrease in AH formation
- Topical CAIs
  - Dorzolamide
  - Brinzolamide
  - Use TID
- Systemic CAIs
  - Acetazolamide
  - Methazolamide
  - Side effects



PROSTAGLANDIN ANALOGUES

- Increase uveoscleral outflow (alternative pathway)
- Latanaprost, travaprost, bimatoprost
- Differences in response between species
  - Works best in dogs
- Side Effects
  - Inflammation
  - Profound miosis

WHERE AND HOW… RHO-KINASE (ROCK) INHIBITORS



- Small, statistically significant but clinically unimportant reduction in IOP in normal dogs and ADAMTS10 POAG dogs
- Combo of latanoprost & netarsudil no more effective than latanoprost alone

ANALGESIA

- Think about what is causing the pain!!
  - Corneal sensation?
  - Reflex uveitis?
  - Elevated intraocular pressure?
  - Treat underlying cause of the pain, if possible
- Topical
  - NSAIDs
  - Cycloplegics
  - Opioids
- Systemic
  - More frequently employed than topicals
  - Opioids
  - NSAIDs
  - GABApentinoids

TOPICAL PAIN MEDICATIONS

- Morphine
  - Can compound as a topical
- Nalbuphine
- Opioids have no untoward effect on wound healing
- Do NOT use topical anesthetics for pain control!!!

CYCLOPLEGICS/MYDRIATICS

- Dilate pupil
- Decrease ciliary spasm
- Stabilize BAB
- Atropine
  - Therapeutic, Long duration
- Tropicamide
  - Diagnostic, Short duration
- Homatropine
- Cyclopentolate
- Scopolamine

DISADVANTAGES AND SIDE EFFECTS OF ATROPINE

- Decreases tear production
- Increases IOP
- Slow GI transit (?)

TAKE HOME POINTS

- Things to think about:
  - Target tissue
  - Properties of the drug
  - Route of delivery
  - Can it be enhanced?
  - Goals of therapy
  - Side effects and contraindications
  - Compliance

Andrew Specht

What's New in Nephrology 1:

Updates for Managing Azotemic CKD patients.

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College of Veterinary Medicine

University of Florida, Gainesville, FL

LEARNING OBJECTIVES:

1. After the session, participants will be able to describe which clinical information is known to significantly impact survival times or well-being in their patients with chronic kidney disease
2. After the session, participants will be able to generate appropriate diagnostic plans to collect the data that is important to understand the likely underlying cause of chronic kidney disease and create an appropriate treatment plan.
3. After the session, participants will be familiar with a variety of treatment options for managing patients with chronic kidney disease and understand how and when to apply these.**INTRODUCTION**

Chronic kidney disease (CKD) is defined as damage or dysfunction of one or both kidneys that has been present or persistent for >3 months. Note that this is not synonymous with, but also does not exclude conditions such as renal insufficiency or renal failure. Unlike acute kidney injury, CKD is characterized by irreversible structural lesions. Although the precipitating insult may no longer be present, CKD is typically progressive, even if progression is very slow.

CKD is common in both dogs and cats. It may be initiated by a variety of congenital or acquired conditions. Whenever possible the underlying etiology of CKD should be determined and treated if reasonable therapeutic options exist. In addition, other comorbid conditions or factors can promote progression of CKD even if they were not the inciting cause. Prognosis for patients with CKD is dependent upon the specific renal disease, the specific underlying cause, and the severity of disease, in addition to numerous other factors.

In order to make informed choices about treatment options, the veterinarian needs to have a certain amount of information about the patient. A diagnostic plan should be proposed that allows the clinician to determine the diagnosis, severity, current complications, comorbid conditions, and risk for progression. Some of the key information that might be a part of the information data base for a CKD patient is included in the table to the right. Not all of these

Data base for CKD patients:

- **Thorough medical history**
- **Complete physical examination**
- **Serum biochemical values**
  - Creatinine
  - SDMA (?)
  - Urea nitrogen
  - Phosphorus
  - Calcium
  - Albumin
  - Sodium, Potassium, Chloride
  - HCO_3 or TCO_2 (or pH?)
- **Urinalysis (w/ sediment)**
- **Urine culture (quantitative)**
- **Urine protein-to-creatinine ratio**
- **Blood pressure**
- **Imaging (radiographs, ultrasound)**
  -kidneys (size, shape, morphology…)

tests should be performed right away, however. For example, the UPC should probably not be performed until there is some certainty that the patient has an inactive sediment, negative urine culture, and is not severely hypertensive. By gathering this information, treatment can be tailored to the specific circumstances of an individual patient. In addition, it is important to remember that CKD is a dynamic and progressive condition. Therefore, serial monitoring is an essential part of any individualized plan.

There are now numerous resources available to veterinary practitioners that offer guidelines for diagnosis and treatment of canine and feline CKD patients. Among these are some consensus guidelines published by the International Renal Interest Society (IRIS) in 2009, and updated regularly, most recently in 2023.[1-3] If you are interested, a lot of information can be found on their website at http://www.iris-kidney.com. The primary IRIS recommendations will be related to their staging system which is primarily based on information about the serum creatinine concentration, blood pressure, and urine protein content. There is also a link at that site to a set of "consensus clinical practice guidelines" which offer recommendations for the diagnosis and treatment of persistent renal proteinuria in dogs.[4] (http://onlinelibrary.wiley.com/doi/10.1111/jvim.2013.27.issue-s1/issuetoc)

While these guidelines/recommendations can be very helpful as a framework for decision making, it is still very important to individualize treatment plans to make sure they fit the needs of individual patients and clients. Although the underlying lesions in CKD are generally irreversible, there are many therapies that have been proposed for slowing progression of the disease. There are also numerous symptomatic and supportive strategies that should be considered in these patients. Some of the key factors that I consider when making treatment decisions in these cases are briefly described below.

Dietary Therapy

First, despite the title of the talk, I do think it is critical to remember that there is very good evidence that dogs and cats with CKD which receive a specially formulated diet tend to have a longer time before they have episodes of felling sick from kidney disease and also live longer than dogs that receive regular dog food.[5-7] While not every dog is willing or able to eat these diets, they should probably be an almost universal recommendation for CKD patients. The main current controversies about these diets are when to start them (as early as stage 1?) as well as whether they may cause some problems (such as hyperkalemia) in some patients with advanced, severe disease.

Hydration status / fluid therapy

Patients with CKD often make more urine than normal and if they do not drink enough to counter-balance this, they can become dehydrated. I routinely recommend serial monitoring of body weight as a helpful tool for assessing water losses and use these to help guide any recommendations about SQ fluid therapy or fluid administration through feeding tubes.

Serum Phosphorus

Many patients with CKD eventually develop high serum phosphorus levels which can be detrimental for a number of reasons and can contribute to progression of their disease, can cause the patient to feel sick, and/or can participate in causing secondary problems including hormonal changes (such as renal secondary hyperparathyroidism). In many cases, simply eating a "kidney diet" can help keep serum phosphorus levels in a reasonable range for a long time. Ideally we may try to keep the phosphorus below certain cut-off values suggested in the IRIS recommendations, and for cats we may consider using FGF-23 to help determine if our control is adequate. If/when the diet is no longer enough to keep the phosphorus level in a desired range, additional medications such as phosphate binders can be added to the therapeutic regimen. There are several different types of medication that can help with this and which one we pick will be dependent on which other problems are present at the same time. This is one of the parameters that we recommend checking fairly frequently (typically, every 3-6 months depending on how stable the other renal values are)

Urine Protein

Proteinuria may be present concurrently with or in the absence of azotemia, and can be a cause or result (or both) of ongoing/active problems in CKD. There is strong evidence to support an important role of proteinuria in renal-cause morbidity and mortality.[8,9] Because of this, we try to control protein loss at a relatively early stage and to minimize the amount of protein being lost over time. Some key principles to consider when evaluating urine protein are verification, localization, magnitude, and persistence. For patients with convincing persistent renal proteinuria the most commonly used test for assessing or comparing urine protein loss over time is a urine protein/creatinine ratio. This will also be our standard test for monitoring progression and response to treatment. In general, the IRIS guidelines call for initiating treatment (diet modification if not already done and RAAS inhibition) for any patient with a ratio over 0.5. I am a bit more conservative and may start treatment only if the ratio is >1.0 or the patient has a low serum albumin. I also recommend checking this value at least a couple times a year for all CKD patients.

Key IRIS recommendations related to urine protein values are summarized below:

Dogs	**UPC 0.2-0.5**	**UPC >0.5**
Stages 1-4	1, 2	1-6
Cats	**UPC 0.2-0.4**	**UPC >0.4**
Stages 1-4	1, 2	1-5

1. *Evaluate for underlying/concurrent disease*
2. *Monitor for progression and/or response to treatment*
3. *Consider kidney biopsy (sent to a specific renal pathology service)*
4. *Renal diet therapy*
5. *RAAS inhibition therapy (make sure patient is not dehydrated)*
   a. *Start with angiotensin receptor blocker (ARB)*
   b. *Consider adding an ACEi, or switching to an aldosterone antagonist if proteinuria not well controlled*
6. *Consider clopidogrel (1-3 mg/kg q24hr) [older recommendation wa sto consider if serum Alb <2.0]*
   a. *Low dose acetylsalicylic acid (1-5 mg/kg q24hr)is also an option if clopidogrel not available*

There are still a couple of major controversies surrounding treatment of persistent renal proteinuria. One is how to evaluate the trade-off between the value of decreasing urine protein loss and increasing uremia when using medications that decrease GFR. The second major controversy is how and when to use immunosuppressive medications in these patients. Both of these are addressed in the IRIS consensus clinical practice guidelines for glomerular disease in Dogs.[4]

Blood Pressure

High blood pressure can also be the cause of or result of progressive changes in CKD patients. Therefore, this is an important part of staging and monitoring CKD patients. There is good evidence to suggest that dogs and cats that are persistently hypertensive may benefit from anti-hypertensive medications.[10,11] Because it is sometimes difficult to obtain accurate blood pressure readings in dogs due to the stress of visiting a veterinary hospital, we typically recommend that repeated tests be performed before starting or significantly changing therapy. I recommend monitoring BP fairly regularly even if it is initially within normal limits (every 3-6 months at on the same schedule the labwork rechecks are performed).

Key recommendations related to blood pressure values are summarized below:

- Patients with moderate or severe risk of target organ damage from hypertension (systolic blood pressures >160 mmHg) should be treated if there is documentation of persistently high values.
- Patients with evidence of extra-renal target organ damage (CNS, retinal, or cardiac effects) should be treated without the need to document persistently high blood pressure values
- The most recent IRIS recommendations (updated in 2023) suggest the following stepwise approach for dogs:
    1. Dietary sodium restriction (**There is minimal evidence for this and it is likely to be removed soon*)
    2. Angiotensin converting enzyme inhibitor (ACEi) therapy at standard doses
    3. Double dose of ACEi
    4. Combination of ACEi and calcium channel blocker (CCB)
    5. Combination of ACEi, CCB, and hydralazine

- The 2023 IRIS recommendations suggest the following stepwise approach for cats:
    1. Dietary sodium restriction (**There is minimal evidence for this and it is likely to be removed soon*)
    2. CCB therapy or ARB at standard doses
    3. Increased CCB dosing
    4. Combination of CCB and ACEi

Electrolyte Balance & Acid-Base Status

The kidneys are responsible for much of the body's regulation of key electrolyte levels (including sodium, potassium, calcium, magnesium, etc...) and therefore patients with CKD are prone to electrolyte imbalances. In particular, we are concerned about chronic losses of potassium and fee/ionized calcium (though the total calcium level may be high due to an inactive component called complexed calcium). In addition, some of the medications commonly used to treat other problems that arise in CKD patients (such as ACEi or ARB for proteinuria) may cause electrolyte problems such as high potassium levels. The periodic labwork performed to evaluate kidney values and phosphorous levels can be used to make sure that patients are not having any issues with this. If a patient does develop electrolyte disturbances, there are various types of supplements or other treatment options that can be utilized to help correct any problems. At this time there is not a lot of specific evidence to support many of these treatments, but they make sense based on anecdotal experience, theory, logic and intuition.

Similar to electrolytes, the kidneys are also responsible for helping to maintain and appropriate balance between metabolic acids and bases and keep the body's pH normalized. In some cases, dogs and cats with CKD will accumulate acids which can also contribute to the progression of their condition. Although measurement of pH

and bicarbonate concentrations is probably the best way to monitor this, the TCO_2 on many serum chemistries can also be helpful. If this value starts to get very low (<16-18 persistently) it could indicate a metabolic acidosis and we may consider providing supplements to correct this. There is evidence for this treatment based on experimental models, but minimal specific/direct evidence for dogs and cats.

Anemia

In advanced chronic kidney disease, anemia is quite common. This may be due to a relative lack of production of erythropoietin, a lack of appropriate response to erythropoietin, decreased red blood cell lifespan, or loss of blood through the kidneys or intestines. If GI bleeding is suspected, acid blocking medications such as H_2 blockers or proton pump inhibitors may be helpful. I would use this type of medication in any CKD patient that I suspect of having GI signs related to their disease. If decreased RBC production is suspected, injections of synthetic erythropoietin analogues such as darbepoetin may be helpful. I typically only use these medications if the patient is clinical for anemia or the Hct is persistently < 25%, but the older more conservative recommendations used a lower cut-off of `20%

Erythropoiesis stimulating medications

Human erythropoietin (EPO) and darbepoetin alpha have both been given to dogs and cats to help stimulate production of RBC in cases of non-regenerative anemia (particularly for patients with chronic kidney disease). One potential risk of EPO is due to the fact that it is a foreign protein. The immune system of some patients may recognize this protein as foreign and start to produce antibodies against it. If this happens, it can eliminate the positive effects of the EPO and in more serious cases these antibodies can start to abnormally recognize and inactivate the dog's own EPO as well, leaving no stimulus for new red blood cell production. This medication is therefore only used for certain diseases and in cases where there are not other good treatment options. There appears to be very little risk of this complication with darbepoetin. Either of these medications can cause erythrocytosis and/or hypertension in some patients.

In the US, the hypoxia-inducible factor prolyl-hydroxylase inhibitor (HIF-PHi) molidustat (Varenzin™) was recently approved for use in cats with anemia associated with chronic kidney disease. It is a relatively new treatment and we do not yet have good comparative data about the comparative efficacy relative to darbepoetin.

Azodyl™

This supplement has been marketed as "enteral dialysis" and there is evidence from the company to show that it may reduce the concentration of BUN in patients with CKD. At this time there is minimal evidence to support an improvement in quality of life, increased time to uremic crisis, or longer survivals. Currently, I neither promote nor discourage its use in my CKD patients.

Porus-One™

This supplement has been shown to reduce the serum concentrations of a couple specific uremic toxins in healthy cats. Anecdotally some feline and canine patients seem to feel a little better with this, but a lot more data is needed to really understand how/when to prescribe this.

Secondary renal hyperparathyroidism

With CKD, excess amounts of the free form of calcium can be lost in the urine and there can be a decreased overall vitamin D activity which reduced absorption of calcium from the diet. To compensate for this, the body will sometimes produce extra amounts of parathyroid hormone which can help retrieve calcium from the bones, but this can cause a loss of bone density and it can also have further negative effects on kidney function as well. Some veterinarians do recommend monitoring for this problem (with periodic checks of ionized calcium and parathyroid hormone levels) and treatment with a vitamin D analogue called calcitriol. This does require careful and frequent monitoring that is often more than what clients are able/willing to pursue.

Key recommendations related to IRIS stage[1-3] are summarized below:

Dogs	**hydration**	**phosphorus**	**Acidosis**	**GI signs**	**Anemia**	**Nutrition & Supplements**	**Hypertension & Proteinuria**
Stage 1	1 (a, b)						*See above*
Stage 2	1 (a, b)	2 (a, b)	3				*See above*
Stage 3	1 (a, b, c)	2 (a, b, c)	3	4 (a, b)	5 (a)		*See above*
Stage 4	1 (a, b, c)	2 (a, b, c)	3	4 (a, b)	5 (a)	6 (a)	*See above*
Cats							
Stage 1	1 (a, b)						*See above*
Stage 2	1 (a, b)	2 (a, b)	3			7	*See above*
Stage 3	1 (a, b, c)	2 (a, b)	3	4 (a, b)	5 (a)	7	*See above*
Stage 4	1 (a, b, c)	2 (a, b)	3	4 (a, b)	5 (a)	6 (a), 7	*See above*

1. Maintain adequate hydration status / euvolemia
    a. SQ or IV fluids to replace deficits
    b. Fresh water available all the time
    c. Parenteral or enteral fluid support to maintain hydration
2. Maintain phosphate in target range: <4.6mg/dL for stage 2, <5.0 for stage 3, <6.0 for stage 4. *(Never <2.7)*
    a. Dietary restriction
    b. Phosphate binders (aluminum-based, calcium-based, lanthanum, sevelamer)
    c. Calcitriol
3. Maintain blood bicarbonate / total CO_2 in the range of 18-24 mmol/L (dog) or 16-24 mmol/L (cat)
    a. Sodium bicarbonate or Potassium citrate (if hypokalemic)
4. If decreased appetite, vomiting, nausea present, consider:
    a. Antiemetics
    b. Proton pump inhibitors
5. Consider treatment for anemia if clinical effects or Hct <20%
    a. Darbepoetin
6. Prevent protein / calorie malnutrition
    a. Appetite stimulants
    b. Feeding tube?
7. Avoid hypokalemia
    a. Potassium gluconate or potassium citrate

KEY POINTS

- Unfortunately, CKD is progressive and irreversible. However, early recognition and intervention may help to prevent or minimize additional damage and slow the progression. This may involve the use of new biomarkers (i.e. SDMA) or a “universal reference range” rather than laboratory specific reference ranges for creatinine.

- Therapy should be targeted to the specific problems identified in the patient, but general guidelines are available to help guide treatment decisions.
- Key targets of therapy are phosphorus concentration, persistent renal proteinuria, and systemic hypertension.

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What's New in Nephrology 2:
Updates for managing proteinuria cases

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LEARNING OBJECTIVES:

1. After the session, participants will be familiar with current terminology and sources of information related to proteinuria in dogs and cats.
2. After the session, participants will be able to generate appropriate diagnostic plans to document and characterize proteinuria in small animal patients.
3. After the session, participants will be familiar with a variety of treatment options for persistent renal proteinuria of clinically significant magnitude and have an understanding of how and when to apply these in there small animal cases.

INTRODUCTION:

In recent years there has been an increasing recognition of the importance of persistent renal proteinuria in our small animal patients. The emphasis on early and accurate detection of proteinuria is supported by a number of different studies that have demonstrated an association between proteinuria and renal-cause morbidity and mortality in both dogs and cats and evidence that the risk of adverse outcomes increases as the magnitude of proteinuria increases. There is additional evidence that some medications such as Angiotensin converting enzyme inhibitors (ACEi) also have reno-protective effects.

Assessment of urine protein is now considered an integral part of the diagnostic work-up for any patient with suspected renal disease. Published consensus recommendations from the American College of Veterinary Internal Medicine in 2005 and the International Renal Interest Society (IRIS) in 2009 and 2013 provide some useful guidelines for classification, diagnostic investigation, therapeutic intervention, and monitoring in our small animal patients. Unfortunately, however, there is still a relative paucity of convincing high quality evidence about whether many of these common diagnostic approaches or therapies really do improve our patients' quality of life or survival times. While this may make some of the recommended guidelines a bit controversial, they can nonetheless serve as a valuable starting point or framework for addressing this challenging but important clinical problem. It is important to keep in mind that these are guidelines, not rules, and it is critical that veterinarians continue to use common sense and their best clinical judgment when determining how to best meet the needs of their individual patients and clients.

CLINICAL INVESTIGATION:

Among the most important principles when trying to determine the clinical importance of a finding of protein in the urine in any individual patient is to think about each of the following considerations:

1. **Verification** (Is it real?) - Know what your test really tells you and consider an additional method of testing if you are not sure about the result.

2. **Localization** – There are some classic broad categories to consider first (pre-renal, renal, post renal; or pre-glomerular, glomerular, post glomerular). However, most of the current literature used a slightly more nuanced version of this that includes four categories:
    - **Pre-renal** – Technically this category only applies to dysproteinemias (multiple myeloma, inflammatory proteins, heme pigments, other abnormal serum proteins…)

- **Transient Renal** – this category incorporates many things previously considered pre-renal such as high blood pressure, high dietary protein, stress, fever, exercise…
- **Pathologic renal** – this category includes glomerular disease, amyloidosis, and tubular disease
- **Post-renal** – This category includes conditions in which protein enters the urine after it enters the collecting system such as UTIs, stones, masses, and bleeding.

3. **Magnitude** – While there are few ways to assess this, the Urine protein: creatinine ratio UPC) is the most widely used and forms the basis for most of the published consensus recommendations. The magnitude of proteinuria is only useful if you are confident that the proteinuria is glomerular in origin. Some other things to think about when interpreting UPC results include:
   - **Day to day variation** – There is substantial variation in the UPC from one day to the next. Variation is highest when values are higher.
   - **Method of collection** – Although there seems to be a common perception that cystocentesis is better, this does not actually seem to be particularly important. Urine can be collected by free catch or by cystocentesis for this test.
   - **Place of collection** – Based on a recent study we did at UF, this may be important as we found that values may be higher in samples collected at our clinic compared to those from home samples. However, at this point we still do not know how to interpret this difference.
   - **Other variables** – A number of other factors have also been evaluated such as container type, confinement, time of day, fasting, protein content of diet, etc… In addition, there are several medications such as steroids, ACEi, etc... which could affect the value so a thorough medical history is always important.

4. **Persistence** – Because there can be cases of transient proteinuria or substantial day-to-day variation, averaging of UPC values from samples collected on several different day s over a 2-3 week period (or alternatively pooling equal volumes from these samples if they can be stored appropriately) is generally recommended before pursuing additional diagnostic testing or treatment for renal proteinuria.

Although renal proteinuria is not always glomerular in origin (renal tubular lesions can also lead to proteinuria), when serial UPCs reveal persistently high values, primary or secondary glomerular changes should be suspected. One key section in the new IRIS Consensus statements included recommendations for diagnostic investigation of dogs with suspected glomerular disease. Key recommendations from this paper are summarized in the table on the next page and include:

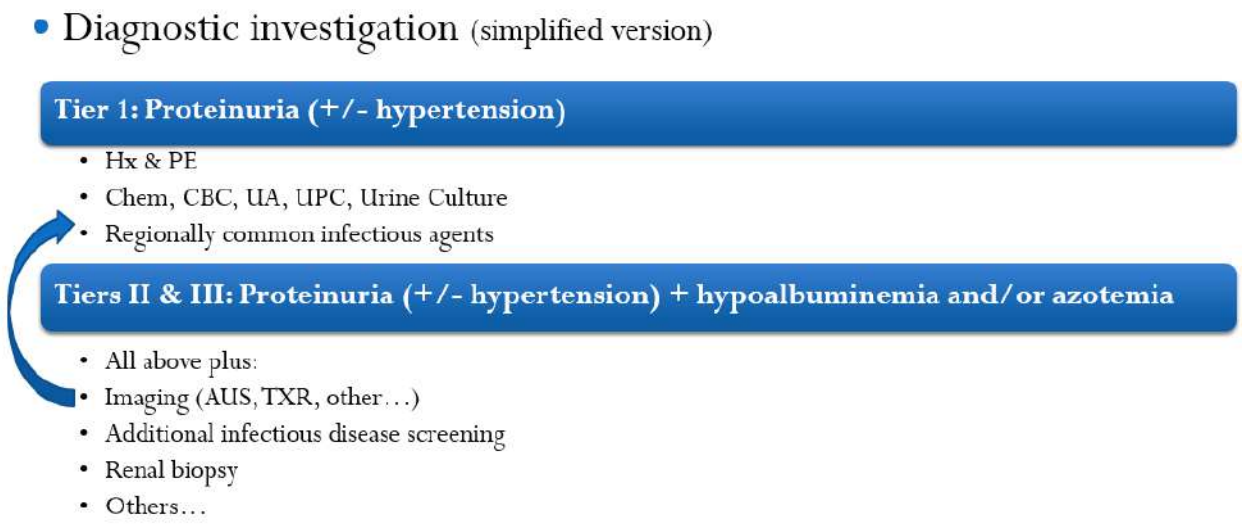
- It is recommended that a classification system involving tiers (based on clinical manifestations of disease - +/- hypertension, +/- hypoalbuminemia, +/- azotemia) be used to facilitate making appropriate diagnostic testing recommendations.
- A hierarchy of importance (essential, recommended, or potentially helpful) is assigned to particular diagnostic tests based on contextual circumstances.
- Some tests are recommended for all cases of suspected glomerular disease, while others are recommended only when other criteria such as proteinuria of high magnitude or other clinical manifestations of disease (as reflected by tier groupings) are present.
- SDS-PAGE is an electrophoresis test performed on urine which can help characterize the proteins in the urine based on size to provide support for localization (likely pre-renal, transient renal, or tubular changes if mostly small proteins vs likely glomerular problem if many larger proteins present.

Key information from the IRIS Consensus statement about recommendations for diagnostic investigation of dogs with suspected glomerular disease

	Hx & PE	Chem, CBC, UA	Urine culture	UPC	Abdominal Ultrasound	Thoracic radiographs	Work-up non-renal dz	Work-up inf dz [b]	Work-up high BP [a]	Work-up low albumin [a]	Classify/work-up azotemia [a]	Renal biopsy [c]	AT, TEG, SDS-PAGE…	BP
Tier I Persistent renal proteinuria w/o azotemia or low albumin	E	E	E*	E	E	R	R[†] PH	R*	E	E*			R[†] PH	PH
Tier II Persistent renal proteinuria w/ low albumin; w/o azotemia	E	E	E*	E	E	E	R	R*	E	E*	E		R	PH
Tier III Persistent renal proteinuria w/ azotemia; +/- low albumin	E	E	E*	E	E	E	R	R*	E	E*	E*	E	R	PH

E = "Essential" (considered part of the minimum diagnostic assessment and of highest priority)
R = "Recommended" (considered part of what should always be done if resources permit)
PH = "Potentially Helpful" (assessments performed in specific circumstances or to be completely thorough)
* If appropriate based on other test results
[†] If magnitude of proteinuria ≥3.5

AT = Anti-thrombin III, TEG = Thromboelastography, SDS-PAGE = sodium dodecyl sulfate-agarose gel electrophoresis
[a] There is more detail about thi sin the consensus guidelines.
[b] Guided by clinical judgement and based on exposure risk in areas where patient lives or has traveled.
[c] There are several sections of the new guidelines that provide information about how to process and interpret renal biopsies. It is recommended that this procedure (including both collection and evaluation components) be performed by experienced personnel.



When to recommend a kidney biopsy:

There is still a fair amount of uncertainty in the veterinary community about the if/when to perform kidney biopsies. At this time, there is still no convincing evidence to support the utility of kidney biopsies in cases of CKD characterized primarily by azotemia. There is an emerging consensus among

experts in the field that they may have value in some dogs with persistent renal proteinuria, especially if there is no response to standard therapy. Somewhat more controversial is the use in acute kidney injury cases.

Although there is no consensus about this, many clinicians believe that the following would each be a relative or absolute contraindication for kidney biopsy: 1) untreated/uncorrectable coagulopathy, 2) uncontrolled hypertension, 3) severe anemia, 4) large or multiple renal cysts, 5) hydronephrosis, 6) extensive pyelonephritis, 7) peri-renal abscess, and 8) end stage renal disease. There are a few risks of the procedure, which include damage to the remaining tissues, hemorrhage from the site, and urine leakage. Proper technique and monitoring as well as having an experienced person performing biopsy collection can minimize these risks.
There are several methods for procuring samples, but the most important consideration is to make sure that the sample contains adequate and appropriate tissue for evaluation. The sample(s) should be taken from the cortex and contain at least 5 glomeruli. Samples are divided and processed according to specific instructions provided by the pathology lab. Whenever possible, samples should be evaluated by pathologists with experience in nephropathology and who employ multiple techniques to fully evaluate the specimens including light microscopy (H&E as well as a number of special stains), immunofluorescence evaluation, and electron microscopy. I use the International Veterinary Renal Pathology Service (IVRPS) and their website had this information (https://vet.osu.edu/vmc/international-veterinary-renal-pathology-service-ivrps).

The main controversy about whether to biopsy kidneys still centers around the lack of direct evidence of a beneficial treatment effect of immunosuppressive therapy in dogs with glomerular disease. The older papers that did evaluate this used steroids as the immunosuppressive medication, while extrapolating from human medicine suggests that a medication such as mycophenolate mofetil might be expected to give better results. Some of the controversies as well as some guidelines about how biopsies might be used to guide therapy are discussed in the International Renal Interest Society Consensus Clinical Practice Guidelines for Glomerular Disease in Dogs).

CLINICAL MANAGEMENT:

Another section of the most recent IRIS guidelines deals with recommendations for "standard therapy" of canine glomerular disease which are similar prior IRIS guidelines, but contain some new information/recommendations.

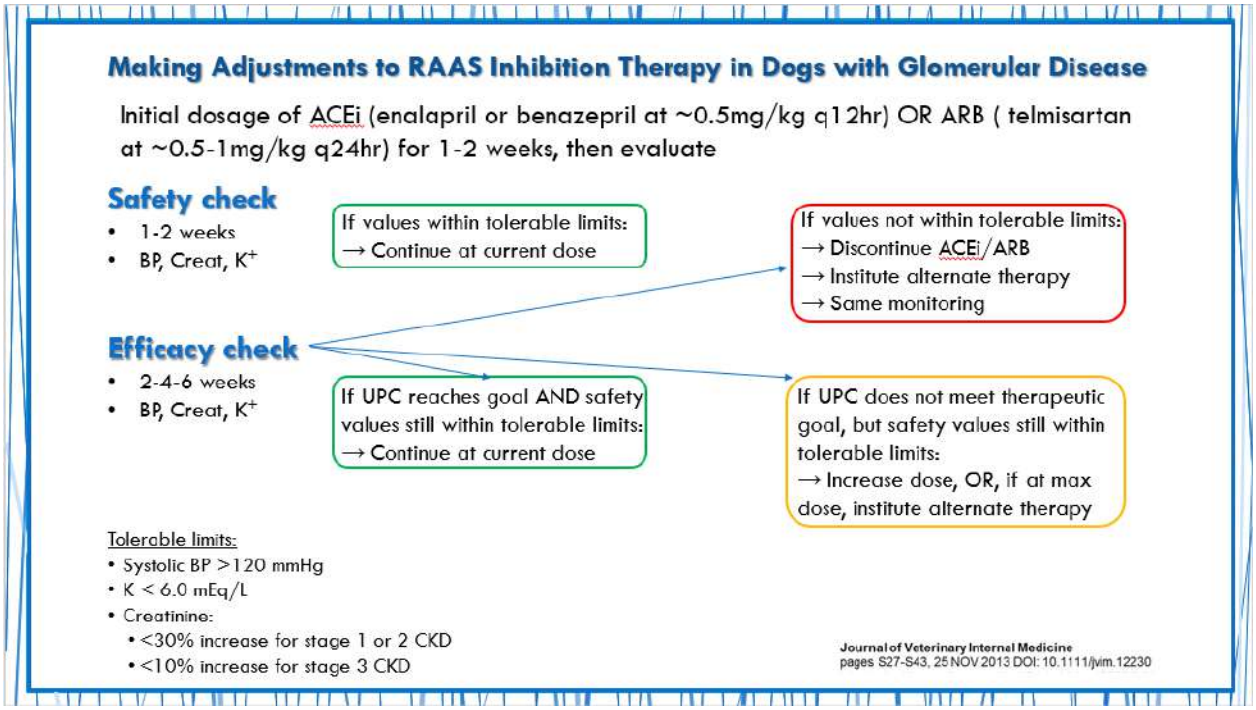
Some key recommendations include:

- Treatment should be considered in any canine patient with persistent renal proteinuria indicated by repeated/average UPC values >0.5 (dogs) or > 0.4 (cats)* (*This is a bit different in that previously treatment was only recommended for non-azotemic patients when the UPC >1.0*)
    - Although the guidelines do not cover cats, there is a current IRIS recommendation to use a cutoff value of >0.4 for deciding when to treat proteinuria in cats.
- Serial UPC can be used to monitor response to therapy, with a reduction of UPC values to < 0.5 for dogs or 0.4 for cats (or by >50% from baseline for either species) considered evidence of success.
- Monitoring of patients treated for glomerular proteinuria should be performed at least once every 3 months and should include medical history, physical examination, UA, BP, and serum albumin, creatinine, and potassium concentrations.
- **ARB** or ACEi should be considered as the initial treatment for most patients
    - Discontinue or lower the dose if:

    - Serum creatinine increases by >30% in a patient with stage 1 or 2 CKD, by >10% in a patient with stage 3 CKD, or by any amount in a patient with stage 4 CKD
    - Potassium increases to >6.0 mmol/L
    - Systolic ABP decreases to <120 mmHg
- Dietary modification including reduced n-6: n-3 ratio of polyunsaturated fatty acids, reduced protein, and reduced sodium is recommended.
- Clopidogrel (1-3 mg/kg q24hr) can also be used as thromboprophylaxis
    - Prior recommendation was to start this if serum albumin <2.0 mg/dL.^
- Anti-hypertensive therapy should be individualized, but is recommended for all patients with reliable/repeatable systolic BP >160mmHg.
- Careful, serial assessments of fluid status (hydration, vascular volume) are recommended and fluid therapy should be used with great caution in nephrotic syndrome patients

**Personally, I find that my patient population seems to have higher UPC than what is commonly reported in the literature, so I have continued to use a cutoff value of >1.0 UPC for dogs and >0.5 for cats when deciding whether to pursue treatment. I do not know if the difference is in the patients or the laboratory, but I suspect the former.*
^Personally, I still typically only use clopidogrel in patients with low serum albumin levels

In addition, Recent evidence suggests that immunosuppressive medications may be indicated in a much higher proportion of patients than has been previously recommended, however this is still mostly dependent upon having kidney biopsy information, and even then, is among the most controversial of the new recommendations. Overall, unless you are very familiar with these medications or the medical literature related to the protein-losing nephropathies, I would suggest consultation with a specialist prior to instituting these additional treatments.



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What's New in Nephrology 1: Updates for managing acute kidney injury patients.

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INTRODUCTION

Acute Kidney Injury (AKI) the current umbrella term used to describe a wide spectrum of sudden onset renal damage ranging from subclinical parenchymal damage to severe acute renal failure. It is best viewed as a continuum of disease with the potential for significant and/or rapid changes over time. Clinically it has typically been recognized in the more advanced or severe forms when the excretory, filtration, hemodynamic, and metabolic functions of the kidney are compromised. However, in some cases it may be possible to recognize AKI before the patient is in a state of acute renal failure (ARF) which may allow for earlier interventions and possibly improved outcomes.

IRIS AKI GRADING

The recently adopted IRIS AKI grading scheme shares some similarities with their CKD staging system in terms of how it has been developed and its use of serum (or plasma) creatinine as the primary factor for separating patients, with two additional criteria for substaging (in this case: urine production and need for renal replacement therapy).[1] One very significant difference is that the CKD staging is specifically intended for use in patients with a stable or steady-state disease whereas the AKI grade is intended only to represent a specific moment in time and in most cases is expected to change significantly over time.

DIAGNOSTIC APPROACH / GOALS

One goal is recognition of AKI in less overt circumstances (i.e. catching cases that are not full blown ARF) by anticipating the risks and testing appropriately. In particular, there has been increasing recognition of the importance of relatively small increases (20-30%) in creatinine (or SDMA) relative to baseline as a basis for diagnosing AKI rather than waiting for overt azotemia. In addition, we are gradually recognizing that pre-renal azotemia (as it has often been described in veterinary medicine) may be more appropriately recognized as pre-renal AKI and that post-renal causes may be much more common than previously appreciated (especially in cats).

A second diagnostic goal is verification of the condition (i.e. is it really acute and is it really primarily kidney related?). There are other conditions that can appear very similar to AKI (or ARF) such as an

Addisonian crisis, and many of the clinically defining features of AKI (such as azotemia or change in urine output) can be seen with pre- or post-renal causes. Furthermore, AKI can be superimposed on CKD in some cases.

A third goal is identify and characterize specific features of AKI that may be acutely life-threatening or have significant consequences for long term patient morbidity/mortality. This is where having a plan to establish a basic data base of information in these patients can be helpful. Some key examples would be to determine the patient's serum potassium concentration, acid-base status, and urine output.

A fourth part of the diagnostic approach is to attempt to determine the specific underlying cause of the AKI if possible. This has significant implications for choosing appropriate treatment plans and may also greatly influence prognosis. Some of the most obvious underlying conditions to consider include infections (pyelonephritis, leptospirosis), toxic insults (esp. medications, foods, endogenous metabolic/electrolyte disturbances, or other known toxic substances), conditions affecting perfusion (heart failure, thromboembolic disease), and obstructions.

CLINICAL MANAGEMENT

Included below are some of the key factors that I consider when making treatment decisions for cases of AKI in dogs and cats. This is not a comprehensive list and it is always important to pay close attention to the specific details of any individual case when making treatment decisions. However, this outline helps me to organize my thoughts when I am dealing with these patients

Hydration status / fluid therapy

Despite the title of this talk, this is an absolutely critical consideration in any AKI patient. The primary goal in these patients is to make sure that we have an adequately hydrated patient and that we attempt to keep them in that state while avoiding states of significant dehydration or hypovolemia, or over-hydration.

Two keys to appropriate fluid therapy are to use calculations (deficit + maintenance + excess losses) rather than estimations (3x maintenance) and to pay close attention to serial weight measurements (as well as urine output and other physical examination assessments of hydration status). In addition, we want to reduce the fluid rate to provide only necessary fluids after the patient is rehydrated and try to avoid high chloride fluids whenever possible.

Correction of life-threatening metabolic disturbances or complications

Hyperkalemia - severe (>7.5mg/dl) or associated with cardiac/EKG abnormalities (↓HR, ↓P, ↑PR, wide QRS, ↑T)

There are several options for treatment including:

- **IV fluid therapy** (especially if the patient is hypovolemic)
- Glucose and insulin (IV)
- Calcium gluconate (IV)
- NaHCO3 (IV)
- Furosemide (IV) -- *Do not use with aminoglycoside renal injury!!*

- Potassium binding agents (oral, rectal)

Metabolic acidosis

There is not much clinical evidence about when control of acid-base disturbances may be beneficial in AKI cases. There is some evidence to suggest that even mild abnormalities may contribute to the establishment and/or perpetuation of the renal tubular damage, but also some contradictory evidence to suggest that acid-base disturbances may be of only minor importance.

A conservative approach is to treat acidosis only if life threatening (pH <7.1, HCO3 <12). A more aggressive approach is to treat even minor abnormalities (pH<7.3, HCO3<17)

**** In either case, the first treatment is to correct hypovolemia/dehydration.***

Specific additional short-term treatment for metabolic acidosis is NaHCO3 (IV). Caution should be used when administering bicarb, since this is not a benign treatment! Correcting metabolic acidosis with bicarb may lead to: ↓ Ca, paradoxical CSF acidosis, cerebral edema, and death. Reassess frequently!!

Simple bicarbonate dose calculation: BD x BW x BS

- BD = bicarb deficit = target bicarb - patient's actual bicarb
- BW = body weight (in kgs)
- BS = bicarb space = volume of distribution correction
  - Range = 0.3-0.9
  - Starting value usually ~0.3-0.6,
  - May be increased if response is inadequate

Oliguria - urine output < 1.0 ml/kg/hr after re-hydration

**The therapies outlined below do not reverse the kidney damage/disease*. They are intended to aid in excretion of metabolic waste products and toxins and buy time for recovery.

Volume expansion (to eliminate any pre-renal component) is essential. Correct detectable deficits initially, but if patient remains oliguric and is not demonstrably over-hydrated …consider giving an additional 3-5% of BW (kg). Reassess frequently and watch for clinical signs of over-hydration. If you have the ability to check CVPs, one option is to give fluids until CVP remains persistently mildly elevated (>6-8) [Use of CVP in this way is controversial]

Diuretic medications are often the next medication choice. However, the patient MUST be rehydrated/volume-expanded first! These medications (with a couple exceptions) generally do not increase GFR, therefore there is generally no improvement in azotemia. The goal is to increase urine volume, which may help correct some electrolyte disturbances and/or help relieve tubular obstruction.

Options for managing oliguria include:

- Furosemide – loop diuretic; avoid when dealing with AG toxicity; I usually start with 2 mg/kg, wait ½ hr and if no increase in urine output, increase the dose to 4mg/kg, give this ½ hour, then go up to 6mg/kg if there is still no improvement. Alternatively, you can give this as a CRI. If this doesn't work, I move on to a different medication or strategy.

- Mannitol – osmotic diuretic; avoid if animal is already over-hydrated?
- Dextrose – osmotic diuretic; little help in most cases, but few adverse effects and may help with other issues (e.g. hyperkalemia)
- Dobutamine – B-1 adrenergic agonist; Little evidence, but at standard doses (5-20 µg/kg/min) it will cause increased cardiac output which might increase RBF and GFR. Be very careful about negative side effects in cats.
- Diltiazem – Some evidence (still controversial) based on theory that it may block vasoconstriction of efferent arterioles by angiotensin II, therefore increasing RBF and maybe GFR and that it may also prevent mitochondrial calcium overload. Dose (dogs) is 0.3-0.5 mg/kg slow push (at least 10-15 min), then 1-5 µg/kg/min. Be careful with this drug
- Fenoldopam – Minimal and contradictory evidence, so still controversial; may increase renal blood flow and urine output during times of severe hypovolemia or decreased cardiac output.
- Dopamine – catecholamine with complex, dose-dependent actions; At low doses (2-5 µg/kg/min) may cause renal vasodilation which may ↑ GFR, but this is very controversial – particularly in cats.

→If patient becomes non-oliguric, provide maintenance fluid therapy and manage other concurrent abnormalities as you would for any other AKI case.

→If patient fails to convert to non-oliguria, two options are available:

1. Interventional treatments such as intermittent hemodialysis (IHD) continuous renal replacement therapy (CRRT), or peritoneal/pleural dialysis. These therapies can aid clearance of specific solutes from plasma by their diffusion into a dialysate solution across a semipermeable membrane. They effectively reduce uremic toxin levels and stabilize electrolyte, acid-base, and fluid imbalances, but have little or no direct benefit to the kidneys. They may also be very useful in eliminating some specific nephrotoxins from circulation. However, the cost and time commitment is very high; cost may be ~$10-15,000 a month. Furthermore, these treatments require specialized equipment and expertise and therefore have somewhat limited availability.

2. Conservative management of fluid, electrolyte, acid-base, and uremic symptoms may be reasonable in patients that are not suffering from severe clinical signs yet. The goal is to buy enough time to see if the patient self-converts to a non-oliguric state. While maintaining adequate hydration, it is critical to avoid over-zealous fluid therapy in these patients. I would give an extremely guarded to grave prognosis for these patients.

Other Key Management Considerations

These patients often feel quite sick and this may include feelings of intense nausea, and/or clinical signs of vomiting, regurgitation, hypersalivation, and inappetence. Nonetheless, we do want to figure out to provide adequate caloric intake / nutritional support during this time. This may include the use of anti-emetic, anti-nausea, and/or acid-blocking medications. Although “kidney” diets are very important in

the long-term management of chronic kidney disease, there is no need to use them in acute situations, and trying to do so may actually create food aversions.

It is important to consider whether there may be other significant co-morbidities and how that might complicate your diagnostic and therapeutic plans. In particular, one commonly overlooked issue is whether there are issues with drug compatibility or whether dosing adjustments are required due to decreased renal excretion.

KEY POINTS

- AKI is a common disorder that is unfortunately associated with high morbidity and mortality. It requires time and patience for effective management and the outcome of most cases is not predicable until it is arrived at.
- Diagnosing early or mild AKI is critical. This allows us to initiate appropriate diagnostic and therapeutic plans before there are life-threatening issues. This also allows us to try to actively prevent further damage, which at least in some cases, may improve the prognosis for survival and recovery.
- Kidneys do have some ability to recover from acute insults, but it is critical that we treat the underlying insult when possible and support the patient to provide time for this recovery.
- Having a well-defined management plan is critical to appropriately care for these patients. In particular, it is important to know what abnormalities are most critical to the patient's well-being and have a plan in place to recognize and treat these.

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Dysuric dogs…What to do when the urine won't flow

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LEARNING OBJECTIVES:

1. After this session, participants will be familiar with some of the most common differential diagnoses for dysuria in dogs.

2. After this session, participants will be able to generate appropriate diagnostic plans to document and characterize dysuria and identify the specific underlying cause.

3. After this session, participants will be familiar with a variety of treatment options for.

INTRODUCTION:

Dysuria is a relatively non-specific term, so further clarification or observation is critical to help identify the most likely differentials. Verification by observation is critical. The underlying diseases would typically be localized to the lower urinary tract, though neurologic diseases or problems with other local tissue that impinge on the lower urinary tract may also be considered. Some examples of refined problems with shorter differential lists are included below:

- Micturition that starts normally but trails off at the end, or where the stream is interrupted – These types of patterns can be suggestive of functional obstruction such as urethral spasm, reflex dysynergia,
- **Strangury** throughout micturition or occurring at times without significant urine output – This is more typical of mechanical obstruction such as stones, masses, urethritis, stricture, etc.

Other clinical urination patterns that are commonly identified in patients with lower urinary tract disease that may be considered types of dysuria include:

- **Pollakiuria** - This can usually be verified through careful questioning. This clinical sign is typically associated with a problem that involves the lower urinary tract. There is not a lot of further refinement for this problem, but we do generally ask if there are other associated abnormalities such as strangury, pigmenturia, periuria, etc. The main differentials in dogs would be infection, stones, neoplasia, or other inflammation. The main differentials in cats are similar but also include feline idiopathic cystitis (FIC), which is actually the most common cause of this problem in cats by a large margin.
- **Periuria** - This is a term that is sometimes used to describe the clinical sign of urinating in an "inappropriate" place such as outside of a litterbox. Verification is typically unnecessary given the nature of the problem. The main localization categories would include lower urinary tract,

neurologic, or behavioral. The main differentials in a cat would be FIC, stones, UTI, neoplasia, behavior, or CNS disease.

GENERATING DIAGNOSTIC AND THERAPEUTIC PLANS:

Dysuria (esp. strangury)

One of the key goals of the diagnostic plan for this problem is to differentiate mechanical/ structural obstruction from function obstruction. You may have some sense of this from the physical examination and observation of micturition, but it is not always easy to determine.

Some simple steps that can be used to help make this distinction include attempting to pass a catheter. There are rare cases in which there could still be a "one-way" mechanical obstruction or where the partial obstruction requires more pressure to open than the patient can generate normally when awake. In this case, a catheter may still pass, so another option is to attempt to express the urinary bladder under anesthesia. If expression is very difficult or impossible even with general anesthesia, a mechanical obstruction should be suspected.

When a mechanical obstruction is suspected or possible, imaging tests can be particularly helpful for localizing and characterizing the type of obstruction. Radiographs tend to be very good at identifying mineral opacity lesions such as uroliths, but it is important to make sure that the films include the entire region of interest and to be aware that there are a few cases in which stones can be radiolucent. Ultrasound can be a useful modality when looking for problems in the urinary bladder or proximal urethra, but may not always identify intra-pelvic or urethral abnormalities. Contrast studies such as a positive cystourethrogram are excellent for localizing obstructive lesions. When available, urethrocystoscopy is probably the gold standard for identifying, localizing, and characterizing obstructive lesions. If a mass is present, cytology or biopsy would be needed to make a diagnosis. Treatment for a mechanical obstruction is based on trying to remove, fix, shrink, open, or bypass the lesion.

If a mechanical lesion has been ruled out, then the focus shifts to identifying or treating "functional" obstruction which is typically the result of a neurologic problem. One of the first steps is to evaluate whether this is generalized or spinal problem or a more localized problem that is only affecting the urinary tract. There are urodynamic studies that could help characterize specific local urinary problems, but these are seldom used in practice. In most cases, if we are confident that there is not a mechanical obstruction, we consider empiric treatment with medications to reduce urethral pressure (phenoxybenzamine, prazosin…), or minimize spasms (oxybutynin…). Last ditch efforts might involve bypassing the problem or mechanically opening the affected part of the tract (i.e. stenting) thought there are significant costs, risks, and client considerations with these techniques.

While the same general principles apply in cats that are described above, they are a bit different than dogs in that at least 50-80% of non-obstructive cases of dysuria in young cats will be due to feline idiopathic cystitis, and the vast majority of the remaining cases will be either stones or more rarely infections so the diagnostic approach may be tailored for this shorter list of differential diagnoses. For older cats experiencing this clinical sign for the first time the list of likely differentials is also relatively short, with uroliths, infections, and cancer being most likely.

Pollakiuria

As described above, the main differentials in dogs would be infection, stones, neoplasia, or other inflammation. The diagnostic approach would therefore typically include urinalysis, urine culture, and imaging tests. If a mass, cytology or biopsy would be needed to make a diagnosis. Treatment would depend on the specific diagnosis.

The main differentials in cats are similar but also include feline idiopathic cystitis (FIC), which is actually the most common cause of this problem in cats by a large margin.

Periuria

The main differentials in a cat would be FIC, stones, UTI, neoplasia, behavior, or CNS disease. The diagnostic approach would therefore typically include urinalysis to confirm that there is evidence inflammation to support urinary tract localization. If this is found, additional tests would likely include urine culture and imaging tests. If a mass, cytology or biopsy would be needed to make a diagnosis. Treatment would depend on the specific diagnosis.

A FEW NOTES ABOUT SOME SPECIFIC DIFFERENTIAL DIAGNOSES FOR "MECHANICAL" OBSTRUCTUIONS:

Uroliths

Diagnosis

- Be aware that not all stones are radiopaque.
- Be aware of positioning on radiographs – easy to miss stones within os penis, if there is superimposition of pelvis/femur, or if the radiograph doesn't include the whole lower urinary tract.
- Be aware of ultrasound limitations – often can't see stones in urethra within pelvic canal.
- A good contrast series or urethrocystoscopy should identify uroliths

Treatment

- The "best" treatment for urethral stones per the available published consensus statement for stoen management is cystoscopic retrieval (utilizing lithotripsy if needed). Practically, this is expensive and there is limited availability so the most common treatment is retropulsion into the bladder followed by cystotomy or dissolution.

Neoplasia

Diagnosis

- Very difficult to pick up on radiographs unless contrast in used
- Ultrasound is likely to identify urinary bladder (i.e. trigonal) masses, but finding urethral tumors may be very challenging.
- Contrast studies or urethrocystoscopy should identify a mass or lesion, but cannot provide a definitive diagnosis (i.e. whether it is a tumor and what kind).
- BRAF mutation testing using urine samples is a non-invasive way to screen for cancers and should catch up to 50% of prostatic carcinomas and >90% of transitional cell carcinomas (TCC).
- Definitive diagnosis requires cytology or biopsy.

Treatment

- Treatment and prognosis may depend on tumor type and location.
    - In some cases, surgical removal may be an option (i.e. penile amputation with urethrostomy, or excision of vaginal leiomyomas).
        - In other cases, partial excision may be a component of multimodal therapy
    - Radiation may also be an option for treatment or adjunctive treatment in some cases
    - Chemotherapy can provide significantly longer median survival times in some patients (esp. TCC)
    - If carcinoma is suspected and the above are not reasonable options for the pet/client, consider non-selective (piroxicam) or COX-2 selective (i.e. carprofen) NSAIDs.
    - If the lesion is obstructive, minimally invasive procedures such as stent placement or laser ablation may provide some symptomatic relief (which can lead to increased median survival times).
    - In some cases where the patient feels good and the client is able to pursue multi-modal therapies, there is a much longer survival time now than what we used to see with TCC.

Infection/Inflammation (proliferative urethritis)

Diagnosis

- Very difficult to identify on radiographs or ultrasound.
- Contrast studies will be abnormal, but difficult to tell the difference between this and neoplasia
- Urethrocystoscopy has a somewhat characteristic appearance, but is not definitive
- Biopsy and culture is still required for definitive diagnosis

Treatment

- When infection is present, a long course (weeks-months) of antibiotics may be needed
- If no infection, either steroids or NSAIDs have been used in these patients.
- Some of these patients (anecdotally higher percentage than other mechanical obstructions) may have bladder atony and require additional treatments for that
    - To help prevent or treat this and keep bladder empty, some patients may require a short term indwelling urinary catheter or placement of a urethral stent

Stricture

Diagnosis

- Very difficult to identify on radiographs or ultrasound.
- Contrast studies and urethrocystoscopy have a characteristic appearance, but can not definitively distinguish this from neoplasia in all cases.

Treatment

- Most commonly treated with a bouginage or balloon dilation procedure, but this may need to be repeated if the stricture recurs
    - A stent can be placed in cases of repeated recurrence
- If this is a distal lesion, urethrostomy can be considered

A FEW NOTES ABOUT SOME SPECIFIC DIFFERENTIAL DIAGNOSES FOR "FUNCTIONAL" OBSTRUCTUIONS:

Reflex dyssynergia / Detrusor-urethral dyssynergia / dyssynchrony

Diagnosis

- Imaging tests may be completely normal in these cases.
- If a voluntary voiding contrast study can be accomplished with fluoroscopy, some dynamic changes may be present to suggest this disorder, but this is very hard to accomplish.
- Definitive diagnosis requires pressure profilometry which is rarely performed in practice.
- Often diagnosis is presumptive based on negative imaging tests, stop/start/spurts pattern of micturition, and response to treatment

Treatment

- Alpha adrenergic medications (i.e. phenoxybenzamine, prazosin) are the mainstays of therapy for this.
- In some cases, if the clinical course has been prolonged, bladder atony can occur which may require additional treatment (bladder emptying, use of a parasympathomimetic like bethanechol)

Urethral spasm

Diagnosis

- Static imaging tests may be completely normal in these cases.
- If a voiding contrast study can be accomplished with fluoroscopy, dynamic changes may be present to suggest this disorder.
- Definitive diagnosis requires urethral pressure profilometry during the voiding phase which is rarely performed in practice.
- Often diagnosis is presumptive based on negative imaging tests, hard stop with continued stangury pattern of micturition, or response to treatment

Treatment

- Anti-spasmodic medications (oxybutynin, tamsulosin) are the primary treatments, but muscle relaxants and/or paralytics could also be considered.
    - Anecdotally, this has a poor prognosis.
- Stenting has been tried when the spasm appears localized on imaging, but anecdotally this does not seem to provide lasting relief and spasms are commonly reported in new locations beyond the borders of the stent when patients are re-imaged.
- Urinary diversion (i.e. tube cystostomy) can be considered a last ditch, palliative treatment.
-

Spinal or local nerve problems

Diagnosis

- Static and dynamic imaging tests are often completely normal in these cases.
- Pressure profilometry can support the diagnosis, but there are no classic patterns and this is rarely performed in practice.
- Often diagnosis is presumptive based on negative imaging tests, finding of overflow incontinence concurrent with strangury/dysuria, and other concurrent neurologic abnormalities.
    - In cases with evidence of other UNM or LMN spinal problems, advanced imaging can localize or diagnose the primary lesion
    - In cases with evidence suggesting a multi-focal or global peripheral neuropathy, additional testing for conditions like dysautonomia or myasthenia gravis may be considered.

Treatment

- This would depend on the suspected underlying lesion/disease.

- May be largely supportive in some cases (frequent expression or emptying of bladder).

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Dribbling dogs…How to fix the leak

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LEARNING OBJECTIVES:

1. After this session, participants will be familiar with some of the most common differential diagnoses for incontinence in dogs.
2. After this session, participants will be able to generate appropriate diagnostic plans to document and characterize incontinence and identify the specific underlying cause.
3. After this session, participants will be familiar with a variety of treatment options for canine urinary incontinence.

INTRODUCTION:

Incontinence

In general, this can be verified by carful questioning or observation. From a localization perspective, this will generally involve the nervous system (typically spinal or peripheral) or the lower urinary tract. In many cases, the differential list for this is relatively short once we have characterized this further and gathered information from the history and physical examination. Some examples of refined problems with shorter differential lists are included below:

- Periodic incontinence (esp. during sleep) in an adult female dog – urethral sphincter mechanism incompetence (USMI), pelvic bladder conformation, influence of concurrent problem (i.e. infection, polyuria), tumor, or other neurologic deficits would be most likely.
- Periodic incontinence (esp. when awake or during activity) in an adult dog – urge incontinence (aka overactive or spastic bladder), urine pooling in vestibule, urethral sphincter mechanism incompetence (USMI), pelvic bladder conformation, influence of concurrent problem (i.e. infection, polyuria), tumor, or other neurologic deficits would be most likely.
- Periodic incontinence (esp. during sleep) in a male dog – urethral sphincter mechanism incompetence (USMI), pelvic bladder conformation, influence of concurrent problem (i.e. infection, polyuria), tumor, or other neurologic deficits would be most likely.
- Constant dibbling incontinence from a young age – ectopic ureters or other congenital problems would be most likely.
- Constant dribbling incontinence that starts during adulthood – Neurologic problems (UMN, LMN, peripheral) are most likely, but consideration for USMI, pelvic bladder conformation, or influence of concurrent problems (i.e. infection, polyuria) are also possible. If this started after an obstruction or procedure, then "atonic" bladder is a primary consideration.
    - If bladder is very large, flaccid, and easy to express, then LMN is most likely
    - If bladder is medium to large, frim, and cannot be expressed easily, UMN is more likely
    - If bladder is small, then LMN, USMI, or others are more likely.

Pollakiuria

This can usually be verified through careful questioning, but is important to distinguish from incontinence. This clinical sign is typically associated with a problem that involves the lower urinary tract. There is not a lot of further refinement for this problem, but we do generally ask if there are other associated abnormalities such as strangury, pigmenturia, periuria, etc. The main differentials in dogs would be infection, stones, neoplasia, or other inflammation. The main differentials in cats are similar but also include feline idiopathic cystitis (FIC), which is actually the most common cause of this problem in cats by a large margin. The

diagnostic approach would therefore typically include urinalysis, urine culture, and imaging tests. If a mass is identified, cytology or biopsy would be needed to make a diagnosis. Treatment would depend on the specific diagnosis.

Polyuria

Direct questioning about or measurement of total daily urine output is often required to confidently verify this problem, but like pollakiuria, it is important to distinguish from incontinence. Polyuria should not cause incontinence, but if there are already problems like USMI that are on the edge on causing problems this could be enough of an added push to see the incontinence manifest. When thinking about localization or characterization of this problem, one way to consider it is to decide if the primary issue is polydipsia or polyuria. Although they often occur together, one is usually the driving force.

If polyuria is considered to be the primary issue, then the main categories for differentials are kidney disease (AKI, CKD, RTA…), rarely lower urogenital tract disease (ie certain UTI or pyometra), endocrine disease (HAC, Addison's, DM, DI…), metabolic (hypercalcemia), liver disease, and medication effects, among others.

The first diagnostic step is to perform tests to help localize this to the urinary tract vs elsewhere which might include serum chemistry, urinalysis, +/- endocrine testing. If these tests are inconclusive we might consider GFR testing, or eventually things like water deprivation or DDAVP trial (these last two would only be considered after all reasonable differentials other than diabetes insipidus and psychogenic polydipsia have been ruled out). If the initial tests support kidney disease, additional imaging studies would almost always be recommended, and potentially specific infectious disease testing.

GENERATING THE DIAGNOSTIC AND THERAPEUTIC PLANS

Incontinence

As described above, one of the first steps with any case of incontinence or dysuria is to try to observe micturition. Immediately afterwards, try to palpate the bladder to gauge the degree of emptying. A neurologic examination should also be included in the physical examination. In most cases, a urinalysis (+/- chemistry and CBC) is important to help monitor for secondary or contributing problems such as polyuria or an infection, but it is generally unlikely to provide a definitive diagnosis (the exception would be for some cases of neoplasia).

In order to completely rule out mechanical/structural issues such as a "pelvic" bladder, short urethra, fistulas, or ectopic ureters, some form of imaging test is generally necessary. Radiographs may help provide some information about the size and position of the bladder or the presence of mineralization. Ultrasound can provide similar information, as well as provide information about the appearance of the bladder wall within the abdomen and may also identify abnormally positioned ureters, especially if they are dilated. Ultrasound cannot generally provide much information about any part of the urinary tract within the pelvic canal. Contrast radiographic studies are actually fairly good at defining the interior borders of the urinary tract, but different types of studies are required depending upon the part of the tract being imaged. CT scans with contrast can be useful for evaluation of ureteral position, but patient positioning may be critical. Cystoscopy, when available, provides excellent visualization of the lower urinary tract including urethra, bladder, and ureteral opening position, and is probably the single best test for ruling out structural problems.

If contributing factors such as polyuria or infection are identified or if a specific structural problem is identified such as an ectopic ureter, then trying to correct those issues first is the primary therapeutic goal. It is critical to inform clients that in many cases this may not correct the whole problem. For example, correcting an ectopic ureter with surgery or laser only eliminates incontinence in 50% of cases, while the remainder may need additional medical or interventional therapy.

If no structural problems are identified, then the problem is most likely functional/neurologic. The presence of non-urinary neurologic signs would often help to localize the problem (i.e. upper vs lower vs. generalized) or suggest certain specific underlying conditions. The absence of neurologic signs beyond the urinary tract would be most suggestive of a local functional problem such as USMI, "pelvic bladder", spasms, and others. There are some urodynamic tests such as urethral pressure profilometry and cystometry that can be performed to try to be more certain about which local problems might be more likely, but there are a lot of challenges with these in dogs and cats and they are therefore rarely utilized.
Some examples of refined problems with shorter differential lists that were briefly discussed above are included here with likely diagnostic tests or empiric treatment options included:

- Periodic incontinence (esp. during sleep) in an adult female dog – urethral sphincter mechanism incompetence (USMI), pelvic bladder conformation, influence of concurrent problem (i.e. infection, polyuria), tumor, or other neurologic deficits would be most likely.
    - Tests: chem/UA to look for confounding problems, imaging to R/O structural problems, +/- urodynamic studies
    - Treatments: if no confounding problems, structural problems, or other neurologic deficits, then
        - Empiric tx with phenylpropanolamine (PPA) +/- estrogen compounds first,
        - Consider collagen or hydrostatic occluder if this fails.
- Periodic incontinence (esp. when awake or during activity) in an adult dog – urge incontinence (aka overactive or spastic bladder), urine pooling in vestibule, urethral sphincter mechanism incompetence (USMI), pelvic bladder conformation, influence of concurrent problem (i.e. infection, polyuria), tumor, or other neurologic deficits would be most likely.
    - Tests: chem/UA to look for confounding problems, imaging to R/O structural problems, +/- urodynamic studies
    - Treatments: if no confounding problems, structural problems, or other neurologic deficits, then
        - Trial of tamsulosin.
        - Trial of PPA +/- estrogen compounds if that fails,
        - Consider collagen or hydrostatic occluder if this fails.
- Periodic incontinence (esp. during sleep) in a male dog – urethral sphincter mechanism incompetence (USMI), pelvic bladder conformation, influence of concurrent problem (i.e. infection, polyuria), tumor, or other neurologic deficits would be most likely.
    - Tests: chem/UA to look for confounding problems, imaging to R/O structural problems, +/- urodynamic studies
    - Treatments: if no confounding problems, structural problems, or other neurologic deficits, then
        - Trial of PPA +/- testosterone or estrogen compounds
        - Consider collagen or hydrostatic occluder if this fails.
- Constant dibbling incontinence from a young age – ectopic ureters or other congenital problems would be most likely.
    - Tests: chem/UA to look for confounding problems, imaging to R/I or R/O structural problems, +/- urodynamic studies
    - Treatments: if no confounding problems, structural problems, or other neurologic deficits, then
        - Trial of PPA +/- testosterone or estrogen compounds
        - Consider collagen or hydrostatic occluder if this fails.
- Constant dribbling incontinence that starts during adulthood – Neurologic problems (UMN, LMN, peripheral) are most likely, but consideration for USMI, pelvic bladder conformation, or influence of concurrent problems (i.e. infection, polyuria) are also possible. If this started after an obstruction or procedure, then "atonic" bladder is a primary consideration.
    - If an atonic bladder is suspected
        - Treatments: consider indwelling urinary catheter, bethanechol, +/- phenoxybenzamine or prazosin.
    - If bladder is very large, flaccid, and easy to express, then LMN is most likely
    - If bladder is medium to large, frim, and cannot be expressed easily, UMN is more likely
    - If bladder is small, then LMN, USMI, or others are more likely.

- Treatments: consider trial of PPA +/- estrogen compounds

A FEW NOTES ABOUT SPECIFIC DIFFERENTIAL DIAGNOSES:

Urethral sphincter mechanism incompetence

This condition is known by several names including urethral sphincter mechanism incompetence (USMI), "spay incontinence", hormone-responsive incontinence and others. This is the most common incontinence diagnosis in small animal practice. It generally occurs in adult spayed female dogs several months to years after OHE, and these dogs often have a "pre-pubertal" vulvar conformation noted on physical examination. Some congenital anatomic or functional abnormalities of the urethra also result in urethral incompetence in adult animals.

A presumptive diagnosis is often based upon ruling out other possible causes and evaluating response to therapy. Definitive diagnosis may be made by confirming urethral incompetence with urodynamic studies, but this is rarely done unless the incontinence is refractory to traditional medical therapies.

Therapeutic options include:

- α-adrenergic agonists (i.e. phenylpropanolamine) – These medications will be effective in ~85-90% of cases. Treatment failures may result from poor compliance or from not administering the medications at appropriate doses or frequencies.
- estrogens (diethylstilbestrol or estriol) – these may be effective in up to ~50-65% of cases when used as the sole medication. They may also act in a synergistic manner with α-adrenergics.
- gonadotrophic releasing hormone (GnRH) analogues – There is less experience with these medications, but they may hold promise as an alternative treatment when other medical options have failed.
- testosterone – This is a controversial treatment, but may be considered in cases of urethral incompetence in adult neutered male dogs.

If medical therapy fails to resolve the problem, further investigation to confirm the diagnosis may be appropriate. If the diagnosis is confirmed, there are a couple more invasive procedures that may work in cases where medical management has failed:

- endoscopic-guided injection of urethral bulking agents such as collagen may help many dogs that are refractory to medical therapies. There is significant loss of efficacy over time and repeated injections may be necessary. Additional endoscopic procedures are being explored but have not yet surpassed collagen injections in terms of safety, efficacy, and cost.
- Surgical procedures such as colposuspension and urethropexy have been used in the past with resolution in up to 50% of cases and up to ~70-75% resolution when performed with concurrent medical therapy. Long term responses may be much poorer, however.
- Surgical placement of a hydrostatic external occluder (also sometimes called an artificial urethral sphincter) have been used with fairly good short-term success. The long-term success of this procedure remains unknown.

Detrusor instability / urge incontinence

In some cases, incontinence occurs when the detrusor muscle contracts involuntarily during the urine storage phase or when there is a low compliance or an altered voiding trigger pressure of the detrusor muscle. These conditions can be confirmed through urodynamic studies such as cystometrography and urethral pressure profilometry. If this is secondary to an inflammatory condition of the lower urinary tract (e.g. UTI, urolith…) the term urge incontinence is used. If no underlying cause is identified, it is classified as idiopathic detrusor instability.

Most often definitive testing is only pursued in cases that have failed empiric therapy for urethral incompetence and in which inflammatory lower urinary tract disease has been ruled out.
Treatment for the idiopathic form involves the use of anticholinergic medications (e.g. oxybutynin, imipramine, dicyclomine…). These medications act to decrease the frequency and strength of detrusor contractions during urine storage. Imipramine may also increase urethral pressure and thus be especially useful in dogs with both detrusor instability and urethral incompetence.

Ectopic ureters

This congenital abnormality is typically diagnosed in young animals. Imaging tests are generally required. Contrast studies and cystoscopy can provide insight into the specific anatomic defect present in an individual patient, since it is often not as simple as just one opening in one place. When available and appropriate (intramural ureters which account for ~95% of ectopic ureters), endoscopic guided procedures are generally recommended over surgical procedures. Many animals with this condition have concurrent abnormalities in anatomy, detrusor function and/or urethral tone regulation.

Pelvic bladder

This term is used to describe a urinary bladder with a trigone that is blunted (rather than tapered) in appearance, and in which the trigone is located within the pelvic canal. There is some controversy about whether this reflects an actual pathologic condition and whether it may be associated with urinary incontinence. Due to the controversy surrounding this condition, a thorough diagnostic workup to rule out other potential causes of incontinence is recommended prior to performing surgery to move the bladder neck cranially.

Ureterocele

This is another congenital abnormality, although it may not be recognized until later in life. A ureterocele is a cystic dilation of the terminal portion of the ureter which often protrudes into the bladder or urethral lumen. Treatment involves incision/excision +/- reimplantation depending upon the anatomic localization of the lesion and the type and extent of any other concurrent anatomic abnormalities.

Ureterovaginal fistula

This may be congenital or acquired, but most often is iatrogenic (when the ureter is accidentally included in a ligature around the vaginal stump. Surgical correction is recommended.

Persistent urachus

This is a very uncommon congenital disorder in small animals that results in urine leakage from the umbilicus. Surgical correction is recommended.

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Bothersome bugs… How to deal with Urinary tract infections

&

Unbothered by Bugs…Is it really okay not to treat SuBClinical bacteriuria?

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LEARNING OBJECTIVES (UTI):

1. After the session, participants will be familiar with current terminology as it applies to urinary tract bacteriuria or infection and recognize situations of complicated and recurrent UTI that may require different management strategies.
2. After the session, participants will be able to recognize some of the diagnostic and therapeutic challenges associated managing complicated UTI cases and be able to recognize clinical situations in which these might alter the management strategy.
3. After the session, participants will be familiar with a variety of treatment options for the management of complicated or recurring UTI including how and when to employ these in their small animal cases.

INTRODUCTION

Bacterial urinary tract infection (UTI) is a relatively frequent problem in small animal practice. It is estimated that up to 14% of dogs will have a UTI at some point during their life. Most of these are female dogs, but make dogs will also occasionally be affected. UTIs are much less common in cats, but the true incidence is unknown.

***Most UTIs are classified as uncomplicated (or sporadic) and will respond to relatively short courses (~10-14 days) of an appropriate antibiotic.** These are cases in which no underlying anatomic, structural, functional, neurologic, or mechanical abnormalities are identified. Clinical signs and laboratory abnormalities may improve within the first 24-48 hours in most cases.

Cases in which the patient has an intact reproductive tract, demonstrable predisposing systemic or local risk factors, or a recent history of UTI should be considered to be complicated UTI. There are also some people who argue that any UTI in a cat should be treated as a complicated UTI. When a patient has multiple UTI within a short time frame, we may classify that as a case of recurrent UTI (and this can be further subdivided into persistent UTI and reinfection)

Complicated UTIs should be treated differently than uncomplicated UTIs. An attempt should be made to identify where the host defenses failed. It is vitally important to know the specific pathogen involved in these cases. Multiple urine cultures and long-term antibiotic treatment are required to ensure successful outcomes.

The following text describes a plan for managing cases in which a patient appears to have a UTI that is refractory to treatment, or in which the patient appears to have recurrent UTIs.

DIAGNOSTIC CONSIDERATIONS:

Confirm the UTI and identify the agent.

Confirmation of infection is important for all UTIs, but is essential for complicated UTIs. The only definitive test for UTI is urine culture. There are several situations in which a UTI may be suspected based upon clinical signs or laboratory analysis, but not confirmed with culture. Dysuria, strangury, hematuria, proteinuria, and pyuria are all common with UTI, but are also all non-specific signs. Likewise, a report of bacteriuria on a urinalysis report may be misleading. Many of the stains commonly used for in house analysis can harbor bacteria and urine that is shipped out may be contaminated and have time for even a small number of bacteria to multiply readily.

The distal portion of the urinary tract in normal animals has a resident population of bacteria. Ideally therefore, urine should be collected in a manner that bypasses this portion of the urinary tract (i.e. cystocentesis). Quantitative cultures are especially important if a sterile sample cannot be obtained by cystocentesis and catheterization or voided samples are used.

In addition to confirming the diagnosis, a urine culture with antibiotic sensitivity data allows for more rational and specific treatment decisions. This also serves as good baseline information if later testing to help differentiate between persistent infection, relapsing infection, or reinfection is necessary.

If the patient has a recent history of UTI, comparison of the organism species and/or sensitivity patterns can help provide insight into whether the previous treatment failed for some reason, or whether there is a new infection present

Distinguish between UTI and subclinical bacteriuria

One paper found that about 9% of "healthy" dogs had subclinical bacteriuria and ~4-5% had the same bacteria present for at least 3 months. Other recent papers have identified bacteriuria in 12-25% of "healthy" older cats. For the most part, the organisms identified are typical for UTI. There is fairly good agreement that patients with no clinical signs and no evidence of urinary tract problems should probably not have cultures performed routinely. ***A good rule of thumb is to reserve urine cultures for situations in which you know in advance that you would treat the infection.***

Differentiate between persistent or relapsing infection, and re-infection.

Persistence or relapse is diagnosed when the same organism continues to infect the urinary tract despite attempted treatment. Essentially, this can be considered a treatment failure (although it doesn't always mean that the therapy was inappropriate - just that it didn't work for this particular case). There are numerous reasons for persistence. These might include iatrogenic factors (e.g. inappropriate dose or treatment duration…), microbial factors (e.g. development of antimicrobial resistance…), host factors (e.g. immunodeficiency…), or other factors (e.g. sequestration of infection within the matrix of a urolith).

Recurrence or re-infection is diagnosed when an animal has multiple UTI. This may be due to the same bacterial species establishing a new infection after a period of time with documented clearance in between, or more commonly, a bacterial species identified as the cause of a UTI that is different from previously isolated species. Frequent re-infection typically implies compromise of host defenses.

A third possibility is superinfection. This is diagnosed when a patient that is currently receiving treatment for a UTI is found to have a different organism present in the face of treatment. Superinfections are typically highly resistant and often occur due to iatrogenic factors or compromised host defenses.

Make sure that treatment failure is not due to iatrogenic or microbial factors.

A thorough review of the medical history, including initial diagnostic workup is warranted if treatment failure is suspected. In addition, drug choices, and drug doses should be recalculated and the duration of treatment reassessed. Other iatrogenic risk factors should be assessed (e.g. catheterization?...). The sensitivity of the organism should be reassessed to make sure that the resistance pattern has not changed over the course of treatment.

Evaluate the patient for compromise of systemic or local urinary tract defense mechanisms

This is also an important step for any UTI, but is especially important for a complicated UTI. Correction of any underlying disorder is crucial for effectively managing these cases. If the underlying defenses cannot be restored to normal, you may need to consider altering the therapeutic plan to account for this. Defense mechanisms that are at work in the urinary tract are listed in the box on this page.

These host defenses can be compromised by many different disease states or conditions. Some of these may be localized to the urinary tract, while others may de secondary to a distant or systemic process. Diagnostic tests must be chosen accordingly.

CURRENT GENERAL MANAGEMENT STRATEGIES:

General guidelines for uncomplicated/spontaneous/sporadic UTI

- Empiric treatment while pending culture results could include:
  - Amoxicillin, TMS
  - NSAIDs
- Antibiotics should not be started in cats until culture results are obtained.
- Antibiotic treatment duration 3-5 days

General guidelines for complicated UTI

- Choice of antibiotic should be based upon culture and sensitivity
- Treatment duration:
  - Consider short duration (~3-5 days) for re-infection
  - Consider longer duration (~7-14 days) for persistent or relapsing infection
  - Previously it was commonly argued that treatment should be continued for 4-8 weeks, and this may still be required in some cases (see below)
  - If treating for a longer period, a culture should be performed during treatment
- Culture should be repeated 5-7 days after discontinuation of antibiotics

Additional guidelines for persistent or relapsing UTI

- Confirm infection (urine culture)
  - Identify organism
  - Localize source of infection
    - Attempt to rule out deep tissue infection, uroliths, etc…
- Review previous treatment

  - Was infection treated as uncomplicated?
  - Was appropriate antibiotic used?
  - Were dose and frequency of administration appropriate?
  - Was duration of treatment appropriate?
    - Even if yes, consider longer course this time.
  - Was owner compliance an issue?
- Review microbial factors
  - Is there evidence of acquired antimicrobial resistance?
- Review possible causes of compromise to host defenses
  - Thorough medical history and physical examination
  - Minimum data base (Chem, CBC, UA)
  - Imaging tests
    - Radiographs (+/- contrast)
    - Ultrasound
    - Endoscopy
  - Urodynamic studies, residual volume measurements, etc…
  - Others as appropriate
    - ACTH stim, evaluation for co-infections (e.g. mycoplasma), etc…
- If no underlying risk factor or cause of treatment failure is identified, pick a new antibiotic and treat as directed above for complicated UTI.
  - Consider tissue levels if applicable (i.e. suspected uropathogenic E. coli)

Additional guidelines for recurrent UTI or re-infection

- Confirm infection (urine culture) and review possible causes of compromise to host defenses as described above.
- If no underlying risk factor or cause of treatment failure is identified, pick a new antibiotic and treat as directed above for complicated UTI.

OTHER CONSIDERATIONS & FUTURE DIRECTIONS

If the approach described above does not result in successful resolution of the problem or if the patient continues to become re-infected on a frequent basis without any identifiable underlying cause (or with an untreatable cause), other therapeutic strategies may need to be employed.[1]

Urinary antiseptics[1]

Occasionally we may have some success with urinary antiseptic medications such as methenamine hippurate. This medication is converted to formaldehyde in acidic urine environments (usually <5.5-6.0). It will not be effective unless the urine is routinely acidic which often requires additional medications such as ammonium chloride or dl-methionine.

Prophylactic antibiotics[1]

We very rarely use this in cases of frequent recurrent UTI or re-infection (not for persistent or relapsing infections). The patient should be culture negative when this is started. Typically, I select a medication that is excreted in high concentration in urine and dose at a time when the urine is likely to be retained for a longer period. One example is to use amoxicillin once a day right before bedtime. This does obviously increase the risk that if another infection develops it will have some antibiotic resistance. This type of antibiotic use is discouraged in the current ISCAID guidelines.

Local infusions[1,2]

In some situations, you might be able to use a medication locally that could not be used systemically. For example, aminoglycosides can be infused into the bladder even in the presence of kidney dysfunction. Or an antiseptic such as chlorhexidine could be infused. There are also local medications such as Tris- or Tetra- EDTA that might help to disrupt biofilms. The obvious limitations of this is the short duration of the treatment and the need for an invasive procedure for installation. This technique is not recommended in the current ISCAID guidelines.

D-Mannose & Cranberry extracts[1,3,4]

D-Mannose sugar may bind to fimbriae of some E. coli strains to inhibit adherence to the urothelial surface. Similarly, proanthocyanidin is the ingredient in cranberry extracts may also inhibit E. coli adherence to the urothelium. There is some in vitro evidence for these, but clinical studies have shown limited or mixed results.

Probiotics & Bacterial interference[5]

Alterations in distal urogenital tract flora may have some role in establishing UTIs and probiotics have been recommended as a treatment strategy in women. So far, there has been no positive effect of systemic or local probiotic use in male or female dogs or cats that I am aware of, but there are some studies in progress.

There is some early data to suggest that it might be possible to displace a problematic UTI organism with a low-virulence non-pathogenic bacteria. This is still not widely studied and these strains are not available for patients yet, but this may be a future treatment for us.

KEY POINTS

- Subclinical bacteriuria does not require treatment.
- Patients with multiple UTI over time should be evaluated for underlying problems related to abnormal urinary tract defenses or systemic immunocompromise.
- Urine cultures are critical to classifying the infections in these patients and selecting the most appropriate antibiotic therapy.
- Although the success is variable, there are some options for preventing or managing recurrence or re-infection in patients for which this is a frequent occurrence.

LEARNING OBJECTIVES (SUBCLINICAL BACTERIURIA):

1. After this session, participants will be familiar with some commonly accepted definitions of "subclinical bacteriuria".

2. After this session, participants will understand the circumstances in which it may be okay to not use antibiotics to treat confirmed bacteriuria.

3. After this session, participants will be able to recognize some of the most common potential dangers related to apparently asymptomatic bacteriuria and how to develop a monitoring strategy that helps mitigate those risks.

INTRODUCTION TO SUBCLINICAL BACTERIURIA:

This is not necessarily a "new" concept, but it has been a topic of discussion in recent years and there has been a significant re-thinking of some clinical practices that were once considered. I have also found that subclinical bacteriuria is something that a lot of veterinarians, including myself, struggle a bit with. It is difficult to know that there is, or might be, a problem presents in your patient and then to make a conscious decision not to treat. Nonetheless, there are some scenarios in which treatment may be unnecessary or even harmful. There are also scenarios in which practical considerations like finances or willingness to pursue invasive procedures may guide us towards a non-treatment approach.

GENERAL INFORMATION:

The term "subclinical bacteriuria" (SB) is now generally accepted to refer to a case in which there is documentation of bacteria in urine by culture, but no clinical signs or evidence of tissue damage or organ dysfunction. In general, pyuria is not considered to move from subclinical to clinical bacteriuria, but structural changes on imaging studies (i.e. bladder wall thickening, pyelectasia) or changes on blood tests (i.e. significant increase in creatinine or SDMA) would move the case into the category of UTI in terms of treatment recommendations. Similarly, the type of bacteria, number of bacteria, and pattern of susceptibility or resistance to antibiotics are not used to classify as subclinical vs UTI, but there are some circumstances in which these factors (particularly bacterial species) may alter the risk to benefit ratio of leaving a subclinical bacteriuria untreated.

Most of the recommendations about how to classify this condition in dogs and cats is based on extrapolation from humans, but that does raise some questions. In particular, while we can usually recognize clinical signs like pollakiuria, strangury, or vocalization, the most common clinical sign of a UTI in people is pain and we know that we are not particularly good about recognizing that in dogs. Therefore, subtle signs such as lethargy or anorexia may have to be considered possible clinical signs in these cases. Another question is whether cognitive impairment may be a clinical sign of UTI. The literature in both humans and veterinary species is unclear about this, but at a minimum suggests that there may be some subset of patients for which there is a connection.

There is a fair amount of evidence that SB is relatively common in our small animal patient population. This includes ~10% of clinically healthy female dogs (all ages) and potentially higher rates in dogs with concurrent diseases (i.e. ~15% in dogs with hypercortisolism). In cats, there is a recognized increase in prevalence in older populations and those with concurrent disease, and overall between 10% to >20% of these cats may have SB.

In the most recent International Society for Companion Animal Infectious Diseases (ISCAID) guidelines for the diagnosis and management of bacterial urinary tract infections in dogs and cats[1], there are sections related to SB and the general recommendations can be distilled to:

Diagnostics:

- Only culture if you would treat a positive result – i.e. if there are clinical signs or clinical abnormalities that might be associated with a UTI
    - Do not culture just because of diseases like diabetes, Cushing's, or CKD

Treatment

- **Antibiotic treatment is not recommended**, UNLESS:
    - There is high risk or evidence of kidney involvement (i.e. any documented AKI)

- It is unclear if clinical signs are related (i.e. anorexia, cognitive dysfunction)
- The patient is unable to display clinical signs of UTI (i.e. neurologic patients)
- There is a known plaque-forming bacteria (*Corynebacterium*)
- There is a known urease-producing bacteria (i.e. *Staph, Proteus*...)
- There is a planned urinary tract surgery or intervention (i.e. ectopic ureter laser ablation)

In addition, there are starting to be some studies to help support these recommendations, though direct comparisons between treatment and control groups are still limited. In one study following older cats, the rates of death or euthanasia were not different in cats that had or did not have SB. In another study of dogs with hypercortisolism, those with SB did receive antibiotics, but had no perceived clinical benefit and half of them had refractory or persistent E. coli with development of antibiotic resistance.

The potential harm in an approach that limits our diagnostic testing or treatment for SB, is that we may not be recognizing all clinical signs or consequences of the bacteriuria or that even if there are no current problems we may be allowing future problems to develop. However, in the absence of clear clinical benefit to treatment, I support the general guidelines from the ISCAID consensus laid out above, especially as I think it helps us improve our antibiotic stewardship efforts. Nonetheless, I do think that if we know bacteria are present, it requires a conversation about our choices with the client and probably a plan for monitoring.

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Imaging the Urinary Bladder

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Overview

Imaging of the urinary tract can provide insights into the cause of urinary tract signs. Evaluation of the kidneys, ureters, urinary bladder and urethra is possible using radiography, although complete evaluation of the urethra is challenging with ultrasound due to the anatomy of the pelvic inlet.

Computed tomography is increasingly used for evaluation of the urinary tract.

Anatomy

The urinary bladder is located in the caudoventral abdomen and has a variable size with smooth margins and an oval to round shape. The urethra exits caudally, through the pelvic canal. The normal prostate is contained within the pelvis, but may lie in the abdominal cavity in older dogs, or in patients with a full urinary bladder. The feline prostate is not visible on plain radiographs.

Imaging Tests

Radiography

Imaging of the urinary bladder can be performed using multiple modalities. Survey radiography offers a rapid evaluation of urinary bladder size, shape, location, opacity and margin. These features can be useful in assessing for evidence of obstruction or potential causes of cystitis as well as displacement associated with trauma, prostatomegaly, or other mass effect. Urinary bladder size can sometimes be an indication of obstruction, and mineral opaque calculi/uroliths or sediment in the urinary bladder and urethra can be identified. However, limitations in contrast resolution can hinder evaluation of the urinary bladder mucosa, bladder contents, and abnormalities in urine. Not all uroliths are mineral opaque, with phosphate and oxalates appearing as mineral opacities on radiographs, and cysteine and urate uroliths typically appearing more soft tissue opaque. Therefore, other imaging methods are often required.

In a male dog that has been neutered at a young age, the prostate is not typically visible as a discrete structure. In intact male dogs, the prostate should not exceed 70% of the distance between the sacral promontory and the cranial rim of the pubis measured on a lateral radiographic projection. In most cases, benign prostatic hyperplasia results in a symmetric enlargement with smooth margins and without mineralization. The presence of mineralization may indicate the presence of neoplasia or a chronic inflammatory process.

The kidneys can typically be evaluated well on radiographic studies. Typical Roentgen signs apply. Evaluation of size, shape, margin, location, number and opacity should be performed.

Contrast studies

To improve contrast resolution and identify some non-mineralized, abnormal urinary bladder contents, contrast cystography can be performed. Contrast agents can be positive (metal opaque - positive contrast cystography) and negative (gas opaque - negative contrast cystography). Both contrast agents can also be added to create a double contrast cystogram. These can be useful to identify filling defects in the urinary bladder caused by non-mineralized cystolithiasis, to assess mucosal margins, and to evaluate urinary bladder wall thickness.

Iodinated contrast agents are used for positive contrast cystography. Non-ionic contrast agents are safer, and are most often used. Barium should never be used for positive contrast cystography. As important, positive contrast can also provide a method to image the urethra. The proximal urethra can often be partially visible on plain radiography; positive contrast urethrography can show the margin and path of the urethra, and help evaluate for luminal obstructive lesions or mural abnormalities such as strictures or masses in male and female dogs and cats. In addition, when trauma to the urinary tract is suspected, cystourethrography can be a useful tool to assess for the location and severity of a suspected rupture. While fluoroscopy is often used for these types of examinations, radiographs obtained at multiple time points during injection of positive iodinated contrast media can sometimes help identify the location of a tear. Therefore, in the evaluation of suspected urethral obstruction or suspected urinary bladder/urethral tears, positive contrast cystourethrography can be indispensable.

Gas is used as a negative contrast agent, and can be equally useful in the evaluation of urinary bladder wall thickness. Room air can be used, though there are reports of air embolism in patients with cystitis in which room air was used for negative contrast. When available, carbon dioxide should be used.

Double contrast cystography can be very useful to diagnose small, soft tissue opaque urolths. When used alone, positive contrast cystography can obscure some uroliths, and negative contrast followed by a small volume of positive contrast can allow these small, soft tissue opaque uroliths to be identifed.

Excretory urography (EU) can also be used to evaluate the kidneys, identifying filling defects, pelvic dilation, and changes in margination. EU studies are also useful for evaluation of the ureters, identifying obstructions, abnormal locations, and ectopia. EU can also be used to obtain a crude estimate of renal function. However, radiographically this test is used less and less frequently. Computed Tomographic EU is very useful for the same reasons, and has supplanted radiographic EU studies in specialty practice.

Ultrasound

Ultrasound can also provide critical information regarding the urinary bladder. Urinary wall thickness and layering can be assessed, as well as the margins of the mucosal surface. The transitional epithelium of the urinary bladder results in thickness that does, of course, vary with volume. In the normal urinary bladder a degree of uniformity is expected, with the normal urinary bladder appearing slightly thicker at the apex, especially in bladders that are only partially filled.

Due to its path through the pelvic canal, the urethra is typically incompletely evaluated using ultrasound. Angling the the transducer caudally can allow a portion of the proximal urethra to be visible; however, the more caudal components are often not seen. Evaluation of the canine prostate

using ultrasound is very rewarding, as size, symmetry, and echogenicity can provide insight into underlying prostatic disease.

Urine echogenicity can also be assessed. Pinpoint echogenic foci can result from cells, protein, mucus and crystals. It can be difficult to tell these apart. Crystals are often gravity dependent and can create artifacts, whereas protein and mucus may remain suspended through the duration of the examination and less frequently result in reverberation. Repositioning of the patient will often result in a redistribution of gravity dependent crystals, and some sonographers prefer to agitate the bladder, creating a "snow globe" effect. Luminal gas within the urinary bladder will create reverberation artifact as well, but will be non-gravity dependent, helping to distinguish it from crystalluria. Gas in the urinary bladder wall will remain static in position, despite any repositioning of the patient, and will also often be visible radiographically. Of course, these imaging findings, conclusions and differentials regarding urine contents must be confirmed via urinalysis, and ultrasound is also very useful to guide cystocentesis.

Kidneys can be evaluated with a 5, 7.5 or 10 MHz transducer depending on the size of the patient and the size of the kidneys. They are located in the reptroperitoneal space, lateral to the aorta and caudal vena cava. Three distinct regions can be evaluated: the renal sinus and peripelvic fat; the renal medulla (hypoechoic); and renal cortex (hyperechoic).

Summary

Radiography and ultrasound both provide important insights into urinary bladder and urethral abnormalities. Ultrasound, with its improved contrast resolution, often provides additional information that can only be achieved radiographically with the addition of contrast agents. However, evaluation of the urethra can be challenging with ultrasound. Therefore, the ability to perform positive contrast cystourethrography can be very important when working with a patient with suspected urethral obstruction.

LIMPING PUPPIES: DIAGNOSTIC IMAGING OF THE MUSCULOSKELETAL SYSTEM

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Introduction

The interpretation of orthopedic radiographs can be a daunting task. While thoracic and abdominal radiography may seem overwhelming, the multitude of cases of lameness cannot be managed without a diagnosis, and radiography is still the primary screening test for lameness diagnosis in dogs. As with any radiographic assessment, having a systematic approach to radiographic interpretation is the cornerstone of accurate evaluation.

Objectives

1. Review a systematic interpretation paradigm for musculoskeletal radiographic review.
    a. Alignment
    b. Bone
    c. Cartilage
    d. Soft tissue
2. Focus on features of aggressive vs. non-aggressive bone lesions
3. Determine next diagnostic step.

Radiographic Findings as Tests[1]

Radiographic interpretation is commonly a challenge. Without a familiar approach, the amount information within an image can be intimidating. However, if one treats radiographic findings as tests with their own sensitivity and specificity, radiographic interpretation becomes similar to the interpretation of blood chemistry analysis or a complete blood count.

For example, you have a 5 year old Rottweiler who presents to you with episodic weakness, periodic anorexia, vomiting, lethargy, and weight loss. On physical examination, the patient has weak pulses and bradycardia. You perform a blood chemistry analysis, and only receive the chloride value, which is low. How sensitive and specific is a low chloride value in your attempt to diagnose this patient?

Similarly, if you look at thoracic radiographs of a patient, and you determine that the patient has an interstitial pattern, what value does that have? How sensitive and specific is that finding for a specific disease process?

In the same way that an entire complement of electrolyte values provides more information about a disease process, radiographic findings are most valuable when added together. In our example, let us say that the

patient was hypokalemic, hyponatremic and hypercalcemic. When this information is added to your signalment, history and clinical findings, you will likely have hypoadrenocorticism at the top of your differential list. From here you may choose a proper diagnostic and therapeutic plan. Likewise, a constellation of radiographic findings is more valuable than a single finding. In a coughing, dyspneic dog with a 4/6 systolic murmur, a caudodorsally distributed interstitial pattern with left-sided cardiomegaly and pulmonary venous distention would lead to you conclude that this patient has left-sided congestive heart failure. Veterinarians are in the business of pattern recognition, whether that be a pattern of abnormal chemistry values or a pattern of abnormal findings on a radiograph.

The purpose of this lecture is to describe a systematic review process for musculoskeletal radiography, to chart out a logical process for interpretation of radiographic findings, and to review common musculoskeletal disease processes.

Roentgen Signs[2]

Roentgen signs (location, opacity, size, shape and number) may seem simplistic, but are fundamental in interpreting radiography. Of these, the location of a lesion may best serve to narrow your list of differentials. Determining whether the geographic center of a lesion is bone, joint or soft tissue significantly affects the list of differentials and focuses the diagnostic plan.

Aggressive versus Non-aggressive Bone Lesions[3]

The first step in evaluating bone lesions is to assess for features of aggression. This is one of the most important determinations to be made early on in the interpretation process as it effectively narrows the differential list. The primary focus of this assessment is the characterization of the features of lysis and periosteal new bone formation; however other features also help in differentiating aggressive lesions from non-aggressive lesions (Table 1). It is important to remember that the presence of one aggressive feature from the list is compatible with an aggressive lesion.

Table 1: Radiographic Features of Aggressive Bone Lesions

	Non-Aggressive	Aggressive
Lysis	Geographic	Moth-eaten Permeative
Periosteal Reaction	Smooth Well-defined Continuous	Irregular Ill-defined Interrupted
Zone of Transition	Narrow Well-defined	Broad Ill-defined
	Slow	Fast

Rate of Change		
Number of Sites	Monostotic	Polyostotic

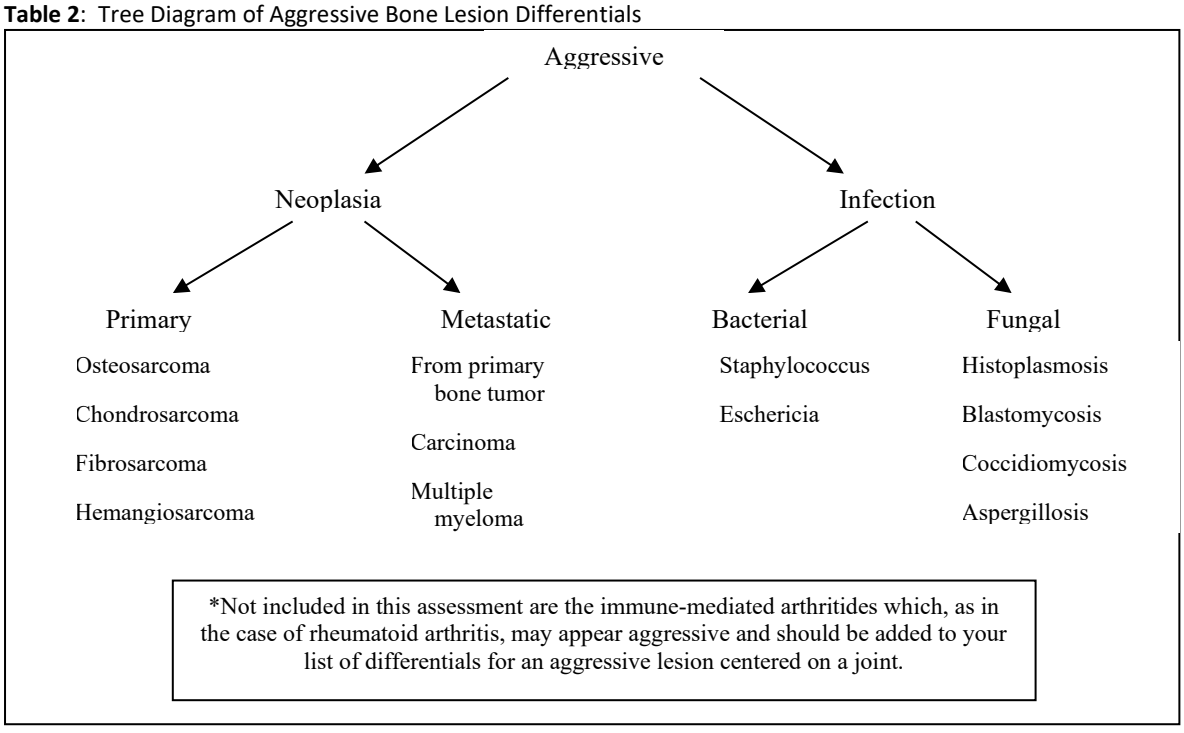
Once a lesion is determined to be aggressive, there is a logical decision tree that can allow you to arrive at a short, reasonable list of differentials (Table 2). This map can be useful, and one can navigate down the appropriate path in light of the patient's signalment, history and clinical findings. An appropriate list of differentials will assist in generating a plan for additional tests such as biopsies and thoracic radiography, or help to institute a therapeutic plan.

Degenerative Joint Disease[3]

Degenerative joint disease (DJD) is a common radiographic diagnosis. Radiographic features of DJD include subchondral bone sclerosis, periarticular new bone formation (osteophytes), and joint effusion/capsular thickening. Severe degenerative changes with marked periarticular new bone proliferation and subchondral bone cysts may mimic aggressive disease. Be diligent in your assessment of aggressive radiographic features.

DJD can be classified as primary (idiopathic) or secondary. Most commonly DJD is a secondary process, occurring as a result of joint instability. Once signs of DJD are noted, the task then becomes to identify the cause of instability. The cause may be evident radiographically, as in a case of osteochondritis dissecans; or it may not be visible radiographically, as in a case of cranial cruciate ligament injury or rupture.

Table 2: Tree Diagram of Aggressive Bone Lesion Differentials



What do I do next?

Once an aggressive lesion is identified, it is important to proceed with obtaining a cellular diagnosis. This can be attained via fine needle aspiration or biopsy techniques. Fine needle aspirates have been shown to have reasonable diagnostic accuracy in cases of osteosarcoma. For other neoplasms, biopsies using a jamshidi needle may be required.

In cases where fungal disease may be possible, fungal titers may also provide additional information on a final diagnosis.

Finally, it is important to stage disease. This typically includes radiography or computed tomography of the thorax, and possibly ultrasonography of the abdomen. In cases of infection, a urinalysis may also be performed. In some instances, other screening tests for metastases, including nuclear scintigraphy and/or whole body CT may be indicated.

Diseases of the Immature Skeleton

Diseases of the immature skeleton, also called developmental orthopedic disease, occur as a specific subset of orthopedic disease that typically do not have features of aggression. This list is relatively concise and these diseases occur in younger patients. However, their imaging features are somewhat unique and characteristic, and therefore should be recognized.

There is a concise list of musculoskeletal diseases that are associated with large breed, rapidly growing dogs. These diseases often have characteristic radiographic appearances and can be easily recognized. The first step in this process is isolating the lameness to determine the radiographic area of interest. For example, it is important to determine if the lameness is joint related or bone related. Remember, it is NOT acceptable to open up the collimation and radiograph the entire thoracic limb. Imaging studies should be targeted to an area of interest to best maximize contrast and spatial resolution.

Disease	Signalment	History and Physical Exam Findings	Radiographic Findings
Osteochondrosis/ Osteochondiritis Dissecans	6-9 month old Large breeds Rapidly growing	Lameness Joint pain +/- Effusion	Subchondral bone defect (flattening) affecting articular cartilage of afflicted joint, often with sclerotic margins Secondary DJD Locations include: • Caudal head of humerus • Distomedial humeral condyle • Lateral femoral condyle • Medial trochlear ridge of the talus • Lateral trochlear ridge of the talus •

Elbow Dysplasia	6-12 month old Large breeds Rapidly growing	Lameness Joint pain +/- Effusion	Umbrella term that includes: • Ununited anconeal process • Fragmented medial coronoid process • Osteochondrosis/ Osteochondritis dissecans • Incongruity Secondary DJD
Hip Dysplasia	6 months old - Adult	Pelvic limb lameness	Subluxation of coxofemoral joint Secondary DJD
Avascular Necrosis of the Femoral Head	1-2 year old Miniature breeds	Pelvic limb lameness	Appearance depends on stage of disease. Early: May be normal or may see lucencies in subchondral bone of proximal femoral epiphysis and metaphysis Late: Flattening and irregularity with remodeling of the femoral head and neck Secondary DJD
Hypertrophic Osteodystrophy	2-7 month old Giant Breeds	Lameness Depression Inappetance Pyrexia Hyperkeratosis Leukocytosis	Typically located at distal radial and ulnar physis Double Physis Periosteal new bone cuff along physis Soft tissue swelling
Panosteitis	5-12 months old Large breeds	Lameness Long bone pain Pyrexia	Solitary or multiple Medullary opacities with blurring and accentuation of trabecular bone Centered on the nutrient foramina of long bones Smooth, well-defined periosteal new bone

Summary

While many clinicians find the interpretation of musculoskeletal radiography a challenge, a systematic approach to the information included in an image results in a maximal benefit. Assessing the aggression of an osseous lesion is the first step. The best use of radiography is often not to attain a definitive diagnosis, but rather to narrow your list of differentials and help plan the next diagnostic test.

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RADIOGRAPHIC EVALUATION OF THE CARDIAC SILHOUETTE

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Introduction

Evaluation of the cardiac silhouette can be a daunting task, and there are several semi-objective measures of cardiac size, and a structured method of evaluating the cardiac shape and contour. These include rules about the number of intercostal spaces a normal heart should cover in the thorax; the height and width of a normal heart as a percentage of the total thoracic diameter; the vertebral heart score; and in the case of assessment of the cardiac shape, the "clock face" analogy.

The diagnosis of heart disease involves further assessment of the cardiopulmonary structures, including the size and shape of the pulmonary vasculature (arteries and veins), the presence of pulmonary edema or pleura effusion, and the presence of ascites.

Objectives

1. Review and understand the different methods of cardiac size and shape assessment in the dog
2. Review and understand the utility of the clock face analogy in assessing cardiac shape
3. Understand the utility and the limitations of such tests
4. Discuss the methodology of successful detection and characterization of heart disease in dogs

Key Points

1. The vertebral heart scale, and other assessments of cardiac size, are useful tests but should not be used in isolation
2. The value of radiographic interpretation of cardiovascular disease is in the complete, summed assessment of all structures rather than in an individual finding
3. Significant breed variation exists, and a range of normal appearances is posible

Cardiac Silhouette Evaluation

The radiographic evaluation of the cardiac silhouette requires the use of all Roentgen signs. It seems strange to think that all Roentgen signs (location, size, shape, number, margin and opacity) can apply here. For example, there is only 1 cardiac silhouette. But if we consider the *number* of chambers that might be involved in cardiac disease (1, 2, 3 or 4), then *number* becomes an important part of our cardiac assessment, and with the evaluation of the *location* of enlargement, determines the *distribution* of disease (right-sided, left-sided, generalized). In addition, while we expect that the heart should be soft tissue opaque, we need to recognize that components of the cardiac silhouette contain fat (pericardial fat) and may influence our assessment of cardiac size if we are not

careful. Also, there are some instances where we may see abnormal mineralization of the aortic valve or coronary arteries.

Heart Size

The vertebral heart score was reported by Buchanan *et al* in 1995 as a method for objectively assessing cardiac silhouette size in dogs, and should typically range from 8.7 to 10.7 in normal canine patients. Since that time, there have been adaptations of this score to cats, and modifications to increase its accuracy in specific breeds, and in puppies. This is a useful score, but it should be noted that, on lateral projections, this test has a sensitivity and specificity of 86% and 80% respectively, meaning that some animals measured normal that had disease, and some animals measured enlarged, with no disease. In addition, the ranges of the VHS can vary significantly with breed, with some normal dogs of certain breeds having hearts that are much larger than the reference range. This further supports the idea that complete assessment of thoracic radiographs is important in reaching an accurate diagnosis of cardiac disease, and familiarity with breed variations is of utmost importance.

Another valuable tool for evaluation of cardiac size is assessment of the number of intercostal spaces (ICS) that the heart covers on a lateral projection. In general, the cardiac silhouette should not cover more than 3-3.5 ICS on a lateral projection.

Finally, an increased cardiac height and/or width can correlate with increased cardiac size and, potentially, cardiac disease. Typically, the heart should be ½ to 2/3 of the height of the thorax on a lateral projection, and ½ to 2/3 the width of the cardiac silhouette on the VD projection at the level of the 5th ICS.

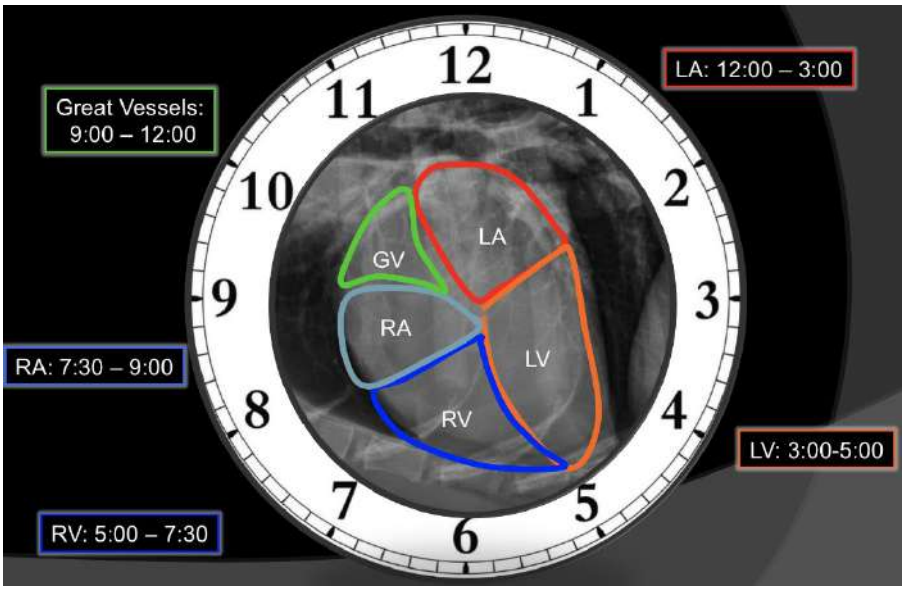
The Clock Face Analogy

The “clock face” analogy is a tool used to assess changes in cardiac shape that can be attributed to enlargements of specific chambers or great vessels. In combination with assessment of cardiac size, the accuracy of cardiac disease diagnosis will be increased.

Other Cardiopulmonary Findings

Pulmonary Vasculature

The pulmonary vessels are a window into the “plumbing” of the cardiovascular system, and thorough evaluation of the pulmonary vessels will allow for determination of congestion (left – sided heart failure, fluid overload), pulmonary overcirculation (left to right shunts, fluid overload), pulmonary undercirculation (pulmonic stenosis, dehydration, cardiovascular shock), or pulmonary thromboembolism (oligemia).



Fluid Accumulation

Fluid in the lungs (pulmonary edema), in the pleural space (pleural effusion) or in the peritoneal space (peritoneal effusion) may also indicate an increase in pressures that relate to cardiac dysfunction. While other differentials for the accumulation of fluid are possible, when these findings occur in conjunction with cardiac enlargements, and in specific regions, they should be included in a succinct conclusion and differential list that involves cardiac dysfunction.

Conclusion

The radiographic evaluation of the cardiac silhouette in the dog should be done in the context of all Roentgen signs, including size, shape, margination, location, number and opacity should be used

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Pulmonary patterns demystified: Radiographic interpretation of the lungs

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Overview:

Interpretation of thoracic radiographs is a daunting task and, without a systematic approach, can be overwhelming. The purpose of this lecture and the series that follow is to aid the practitioner in developing an organized approach to the review of thoracic radiographs to promote thorough review and understanding of the lesions observed and their meaning. While this particular talk will focus on the evaluation of the extrapleural and pleural spaces, there will be additional information in later sessions that address these abnormalities and their relationship to pathology in other compartments of the thorax.

Objectives:

1) Review the 4 part interpretation paradigm
2) Use these concepts to begin your complete evaluation of the thoracic radiograph.
3) Understand the concept of an “extrapleural sign” and how it helps distinguish between extrapulmonary and pulmonary lesions.

Key Points

1) Technical factors including technique, phase of respiration and the positioning of the patient have to be taken into account when interpreting thoracic radiographs.
2) Radiographic abnormalities are non-specific and one must thing in terms of what the next step would be to reach a definitive diagnosis.
3) The pathophysiology of many pulmonary diseases do not equate with a specific pulmonary pattern.
4) One should try to compartmentalize radiographic abnormalities into extrathoracic, pleural, pulmonary and mediastinal (including cardiac), recognizing that any disease can have multicompartmental components.
5) One should try to determine the anatomic location of pathology within the lung first and foremost and then worry about the pulmonary pattern. Even though there may be several pulmonary patterns, one must identify the dominant pattern in order to evaluate for differentials.
6) Pleural effusions should always be evaluated using cytology and culture and sensitivity unless post trauma and the effusion (assumed to be hemorrhage) is resolving over several days.
7) Follow-up radiographs should be obtained in rapid succession if warranted (within the same day or within 24 to 48 hours).
8) Edema from cardiogenic causes responds rapidly to diuretics unless the dog or cat has been in chronic failure and is resistant to the diuretics.
9) Edema from non-cardiogenic causes will not clear rapidly, but may take several days to see significant resolution of pulmonary abnormalities.

Interpretation Paradigm

In an effort to simplify radiographic interpretation of the thorax, a 4 part interpretation paradigm can be helpful. The thorax can be deconstructed into the extrathoracic structures (including the osseous structures, body wall, and diagphragm as well as the portions of the abdomen and cervical region in the collimation); the pleural space; the mediastinum (all of it, including the heart); and finally the lungs (pulmonary parenchyma and pulmonary vessels). These regions can be evaluated separately as long as it is understood that most diseases are multicompartmental, and this paradigm is for simplification purposes only.

The Thoracic Radiographic Examination

The thoracic radiographs should be made on peak inspiration and should be centered over the heart so that the thoracic inlet and the caudal dorsal lung lobes are obtained on the same radiograph. This may not be possible with a 14" x 17" on a large breed dog (Great Dane), in which case two cassettes are required for each view (cranial thorax and caudal thorax) making sure there is overlap in the middle. The images to be make include a dorsoventral or ventrodorsal and a right and left lateral. The three view thorax has become the standard of care in veterinary medicine so do not leave yourself short. The technique used is typically a high kVP and low mAs technique with the highest mA and fastest time station being used to obtain mAs techniques in the 1 to 3 range. For a small dog or cat, the kVP may still be in the 50 to 60 range.

Positioning is critical for accurate interpretation. The ventrodorsal should be straight with the sternum lined up with the thoracic vertebrae and the rib heads should be overlapping on the laterals. Sometimes a triangular sponge is required to lift the sternum away from the table on the lateral radiographs in order to get the sternum and spine parallel to each other prior to taking the radiograph. Peak inspiration means that the cupola of the diaphragm is drawn caudal to the cardiac silhouette and the caudal dorsal lung margins reach to the level of T12-13 in dogs and T13-L1 in cats. An expiratory radiograph will negatively impact your interpretation skills in two primary ways. First, the heart will always look big relative to the overall thoracic volume and second, the lungs will look "whiter" than normal. If you take only right lateral radiographs of small dogs, that present for a cough, and the radiograph is made on expiration, the dog will have a big heart and pulmonary edema every time (both are "fake-outs!"). If you were to take the DV or VD you would see that the thorax is really normal.

External artifacts (skin folds, nipples, etc.) must be recognized and not attributed to pulmonary pathology. Expiration, under exposure and obesity will all increase the overall lung opacity, thereby falsely thinking that one is dealing with pulmonary edema or some type of pulmonary pathology as previously state.

<u>The Extrathoracic Structures:</u>

Soft Tissues

The soft tissues surrounding the thorax should be evaluated. Fascial planes should be outlined by fat; soft tissues should have a uniform homogenous density. The position of the forelimbs should be noted because their superimposition over the cranial thorax adds to that region's density. Skin folds are created when patients are positioned for thoracic radiography and these can be identified as tissue dense lines which have a distinct, dense margin. These lines can usually be traced beyond the thoracic margins. The nipples and other cutaneous structures may be superimposed on the lung and mimic intrapulmonary nodules. Some authors have recommended coating the nipple with barium to positively identify them, however in most cases examining the patient and confirming the location of the nipples is enough. Pleural masses may extend into the external soft tissues; therefore, intercostal swellings should be critically evaluated. The hepatic and gastric shadows should be examined noting their position, size, shape and density. If hepatic or gastric abnormalities are observed or suspected an abdominal radiograph should be obtained.

Bony Structures

The vertebral column, ribs, sternebrae and bones of the proximal forelimb are usually included on a thoracic radiograph. A technique that is correct for thoracic viscera usually underexposes these bony structures.

Positioning for thoracic radiographs is not ideal for evaluation of the bones; however, the vertebral column, ribs, sternebrae, scapulae and long bones should still be examined. A radiograph, properly exposed for evaluation of bony structures, must be obtained if abnormalities are observed.

The vertebral column should have a smooth continuous contour. Disc spaces should be uniform; rib articulations and joint spaces symmetrical. An apparent decrease in bone density will be observed along the ventral aspect of the vertebral bodies because of superimposition of the lung. The pattern within the lung may create the appearance of irregular vertebral body density; careful examination will identify the pattern as pulmonary in origin.

On the lateral radiograph each pair of ribs should be superimposed where they articulate with the vertebrae; additionally, the costochondral junctions should appear at the same level. Because of the curvature and density of the ribs, abnormalities may be subtle. Tracing the ribs from right to left across the thorax on the ventrodorsal view facilitates lesion detection. The rib density should be uniform and a faint cortical shadow should be visible. A rib head, neck and tubercle can be identified proximally; however, the size and shape of these structures are variable. The costochondral junctions are slightly widened and the costal cartilages may calcify in an solid, irregular, granular or stippled pattern. Calcification may begin before one year of age, usually increases with age, and may appear irregular or even expansile. Malalignment or breaks in the costal cartilages are common and, although these may represent fractures, are normal ageing changes and are usually without clinical significance.

In addition to the ribs and costal cartilages the rib spacing should be evaluated and should show uniformity from side to side. Uneven spacing suggests uneven inflation of the lung and may reflect soft tissue, rib, pleural, pulmonary or diaphragmatic pathology.

The ribs of certain breeds such as the Dachshund and Basset Hound first curve outward then inward at or near the costochondral junction. This is followed by an outward then inward curve to their sternal attachment. In the ventrodorsal radiograph of these dogs the thoracic wall conformation produces an extra density over the lung. This should not be mistaken for pleural or pulmonary disease.

The sternebrae and their intersternebral cartilages should be evaluated. The amount of mineralization of the chondral and intersternebral cartilages usually increases with age and is greater in larger dogs. Malalignment of sternebrae is frequently observed and is insignificant unless accompanied by intra- or extrathoracic soft tissue swelling or clinical signs. Sternebral malformations are usually insignificant. Variation in the size and number of sternebrae and in the shape of the manubrium and xyphoid are common.

Thoracic conformation varies with breed and each variation influences the appearance of the thoracic viscera. It is important to note the animal's thoracic shape and evaluate the thoracic viscera accordingly. Three major categories may be observed.

1. Deep and narrow - such as Doberman Pinschers, Afghan Hounds, Collies, Whippets
2. Intermediate - such as German Shepherd Dogs, Labrador Retrievers, Dalmatians
3. Shallow and wide - such as English Bulldogs, Basset Hounds, Dachshunds

Some variation occurs even within the same breed; therefore, categorization should be based on each individual's conformation.

Diaphragm

The diaphragm defines the caudal margin of the thoracic cavity. It is visible radiographically because the air filled lung contacts its smooth cranial surface. With deep inspiratory efforts the diaphragmatic attachments to the thoracic wall may be identified on the VD or DV views as peaks along the diaphragm margin. This has been referred to as "tenting" of the diaphragm. The caudal margin of the diaphragm blends with the shadows of the liver and stomach. The diaphragm is composed of a right and left crus in its dorsal aspect and a central cupula or dome in the ventral portion. There are three separate openings through the diaphragm for the aorta, esophagus,

and caudal vena cava. Because of its curved shape the diaphragmatic profile changes with the animal's position and the x-ray beam angle. The diaphragm's shape is also influenced by respiratory phase, pressure from abdominal contents, breed, obesity and age. Because of the diaphragm's shape aerated lung will be superimposed over the liver and pulmonary pathology may be readily identified in that area.

In the ventrodorsal and dorsoventral radiographs the cranial peak of the cupola frequently lies to the right of the midline. The caudal vena cava interrupts the diaphragmatic outline at about this point. The crura may be identified as separate structures overlapping the cupola laterally and curving caudally toward the midline blending with the vertebral column at about T-10. The crura are more often evident on a ventrodorsal view; this varies between individuals and one, both or neither crura may be seen. On the lateral radiograph all 3 portions of the diaphragm are usually evident with the dependent crus usually cranial to the opposite crus. The margins of the caudal vena cava interrupt the outline of the right crus. When the animal is in right lateral recumbency the air filled gastric fundus may be identified caudal to the left crus. Fat within the falciform ligament ventral to the liver may outline the diaphragmatic cupula on the abdominal side. This may be a helpful finding in patients with pleural fluid in which diaphragmatic hernia is being considered as a possible diagnosis.

The Pleural Space

The pleural space is a potential space between the visceral and parietal pleura and between the adjacent visceral pleura between lung lobes. In normal animals a small amount of serous fluid is present within this space however, because of the size of this space and the small amount of fluid which it contains, it is not radiographically visible. Fluid or air accumulation within this potential space or fibrosis or calcification of the pleura will make the pleural space visible. When the direction of the x-ray beam is parallel to an interlobar fissure it may be radiographically evident as a thin linear tissue density. The location of the interlobar fissures within the thorax are fairly consistent and these should be specifically examined. Fat may accumulate beneath the parietal pleura in obese animals and be visible. The pleural space width may be accentuated on an expiratory radiograph in a normal animal.

The Mediastinum

The mediastinum is formed by the reflection of the two parietal pleural mesothelial linings. Some questions that are pertinent to the assessment of the mediastinal space, excluding the cardiac silhouette would include: Is the mediastinum normal for size, margins, shape and opacity? Is there a mediastinal mass or any fluid? Is there mediastinal air and if yes, is it focal and contained in a mediastinal structure or is it generalized within the mediastinal space? Is there a mediastinal shift? If the answer to any of these questions is yes, then the practitioner should define the exact anatomic position of the abnormality. In other words is the abnormality focal (cranial, middle caudal and dorsal or ventral in position) or generalized.

The Cranial Mediastinum

The dorsal aspect of the cranial mediastinum is characterized by soft tissue opacity that is divided by a radiolucent tube called the trachea. Other anatomic structures that are present in the dorsal aspect of the cranial mediastinum include the cranial thoracic vessels (aortic arch, brachiocephalic trunk, left subclavian, azygous vein, cranial vena cava), fat, nerves (vagosympathetic trunk), esophagus and cranial mediastinal lymph nodes. The trachea and its walls are normally the only structure that is visualized on the lateral and VD/DV radiograph. The trachea is normally located in a central to right sided position on the VD/DV radiograph. The trachea normally diverges away from the vertebral column on the lateral radiograph.

The ventral compartment of the cranial mediastinum is made up the mediastinal reflection of the right and left cranial lung lobes. On the VD radiograph the ventral mediastinal reflection can be seen and defined by the left and right cranial lung lobes. The left cranial lingula will extend into the right cranial hemithorax in large breed dogs, but not cats, brachiocephalic dogs or obese small dogs.

The thymus is a normal structure seen in immature cats and dogs that has a typical appearance of a triangular soft tissue opacity extending from a craniomedial position to a caudolateral position in the cranioventral mediastinal reflection. This called the “sail” sign. On the lateral radiograph a curvilinear soft tissue structure may be seen (inconsistent even if the thymus is present on the VD/DV radiograph). While the thymic enlargement is typically located to the left of the vertebral column, enlargement of the sternal lymph node will typically result in widening of the ventral mediastinal reflection in a fusiform to oval shape on a rightward or midline position, superimposed over the cranial thoracic vertebral bodies on the VD/DV radiograph. Also within the cranial ventral mediastinal reflection, the internal thoracic vessels (artery and vein) are found. On the VD radiograph, the cranial vena cava and trachea will be located just rightward of the thoracic vertebral bodies.

Is there air present in the mediastinum? Is the air focal or generalized? Generalized gas accumulation within the cranial or caudal mediastinum must be distinguished from air within the esophagus. Cervical trauma, external penetrating wounds, esophageal or tracheal rupture/tear, venipuncture or transtracheal washes can result in a pneumomediastinum. As air accumulates within the cranial mediastinum, various structures and edges of soft tissues that normally will border efface and become apparent. If the pneumomediastinum becomes severe then the air will dissect caudally into the retroperitoneal space via the aortic hiatus through the diaphragm. A pneumomediastinum will only be seen on the lateral radiograph unless the VD/DV is obliqued. A pneumomediastinum may lead to a pneumothorax but a pneumomediastinum will not result from a pneumothorax as the air collapses the mediastinal space between the two pleural reflections. The key to diagnosing a pneumomediastinum is the ability to see soft tissue structures within the cranial mediastinum that are usually not seen on normal radiographs. These structures would include the outer (normally not seen) and the inner (normally seen) margins of the tracheal wall, the entire thoracic aorta, the great vessels of the cranial mediastinum, the azygous vein, and the longus colli muscles. Gas on the outside of the trachea, is called the tracheal stripe sign and is consistent with a pneumomediastinum. Gas within the cranial thoracic esophagus will cause the ventral border of the esophagus to border efface with the dorsal border of the trachea creating what is called the tracheo-esophageal stripe sign.

Is there a mediastinal mass or fluid? Common causes of mediastinal masses include lymph node mass(es) or enlargement, thymic mass (thymoma or thymic lymphoma), esophageal enlargement (dilated as with generalized or partial megaesophagus), mediastinal hemorrhage (thymic rupture in an immature dog or hemorrhage secondary to trauma or coagulapathies). Typically, on radiographs of animals with craniodorsal mediastinal masses, there will be symmetrical widening of the cranial mediastinum on the ventrodorsal radiograph with caudal displacement of the right and left cranial lung lobes. Mediastinal tumors usually arise from the thymus, lymph nodes, ectopic thyroid tissue or connective tissues of the dorsal and cranial mediastinal structures. Mediastinal fluid may accumulate due to the presence of a mass, hemorrhage or mediastinitis, or can be secondary to esophageal perforation.

Mediastinal masses can also be accompanied by pleural fluid. The presence of the fluid can make diagnosis of the mediastinal masses difficult. Dorsal deviation of the trachea in the presence of a moderate or severe volume of pleural fluid cannot be used to infer the presence of a mediastinal mass, even with caudal displacement of the tracheal carina. Repeating radiographs following thoracocentesis can be helpful. Positional films may be more useful for evaluating the cranial mediastinum. An erect horizontal beam DV or VD film is preferred. Using this positional radiograph, the pleural fluid will drain to the caudal thorax (now in a down, gravity position) and the lungs to outline the lateral margins of the cranial mediastinum quite clearly. An alternative technique is to perform a non-selective angiogram cranial vena cava. A large bore catheter is placed in either jugular vein and a bolus of water-soluble iodinated contrast medium (400 to 800 mg I/kg) is injected as quickly as possible. Mid way or simultaneous to the end of the contrast medium injection, a lateral radiograph is obtained centered over the thorax. If a cranial mediastinal mass is present there will be dorsal displacement, compression and/or distortion of the cranial vena cava. The cranial vena cava should also be evaluated for the presence of intraluminal abnormalities. Filling defects within the contrast that have a consistent appearance on multiple films suggest thrombus formation or vascular invasion by tumor. A crude assessment of cardiac size may also be made by this technique. If a pericardial abnormality is suspected (pericardial effusion or peritoneopericardial diaphragmatic hernia), the true heart versus the cardiac silhouette can be determined.

Radiographic signs of a mass or fluid can include increased overall soft tissue opacity on the lateral film, elevation of the trachea, widening of the cranial mediastinum to exceeds the width of the spine on the VD or DV film (except in brachycephalic breeds or obese patients), blurring or obliteration of the cranial border of the heart.

Is there an ipsilateral or contralateral mediastinal shift? A mediastinal shift is secondary to a pleural or pulmonary abnormality. It may occur either due to volume loss or increased volume in the adjacent lung lobe or the pleural space in one hemithorax. An ipsilateral mediastinal shift is secondary to volume loss (atelectasis) of a cranial lung lobe or a pleural or lobar mass resulting in a contralateral mediastinal shift. The lungs should be evaluated for evidence of a mass, overinflation or volume loss and the pleural space for a mass and/or fluid. A mediastinal shift will occur within minutes after the animal is anesthetized. A common cause of atelectasis can be secondary to prolonged lateral recumbency, general anesthesia or following thoracic surgery.

The sternal lymph node is located in the ventral compartment of the cranial mediastinum. It is located dorsal to the second or third sternebrae on the lateral radiograph. The sternal lymph node receives lymphatic drainage from the pleural and peritoneal surfaces of the diaphragm and organs of the abdomen. Sternal lymphadenopathy is commonly associated with multicentric lymphoma in dogs or peritoneal inflammatory or neoplastic disorders. The sternal lymph node is easier to recognize in the dog than the cat because of the ventral lung lobe mediastinal reflections. These mediastinal reflections are not as prevalent in the cat and thereby the sternal lymph node is seen as an ill-defined oval increase in soft tissue opacity dorsal to the second sternebrae. On the VD radiograph of a dog with sternal lymphadenopathy, there will be an “S” deformity and widening to the ventral cranial mediastinal reflection with focal retraction of the cranial lung lobes (not symmetrical widening as with a dorsal cranial mediastinal mass).

The esophagus

Is the esophagus normal? The normal esophagus is not visualized. The esophagus runs from a dorsal cranial mediastinal position to a caudodorsal mediastinal position over the heart base area. The esophagus inserts into a slightly leftward opening in the mid dorsal diaphragm, at the esophageal hiatus. The esophagus lies just to the left and dorsal aspect of the trachea. In the caudal mediastinum the esophagus is in a central position superimposed over the caudal thoracic vertebrae. In the cranial thorax and just cranial to the thoracic inlet, the esophagus lies in a dorsolateral position (leftward) and can cause the trachealis muscle and dorsal tracheal membrane to indent in to the tracheal lumen. This is called a redundant dorsal tracheal membrane and has been considered a type I tracheal collapse. However, this can be seen in numerous dogs without clinical signs of coughing and should not be considered a significant abnormality without the appropriate clinical context.

Many normal dogs will have a short, thin, linear gas shadow within the esophagus just cranial to the tracheal bifurcation, most commonly identified on the left lateral radiograph. This should only be regarded as abnormal if it persists unchanged on multiple films. Heavy sedation and anesthesia frequently cause esophageal dilation so megaesophagus can only be diagnosed in conscious animals. Moderate to severe dilation of the cranial thoracic esophagus will cause a mass effect and displace the trachea in a ventral and rightward position. The apposed esophageal and tracheal walls are seen as a soft tissue stripe if the esophagus is gas filled and may be confused with a pneumomediastinum. But this stripe is thicker than the tracheal stripe. The walls of the caudal esophagus are outlined by luminal gas as two thin soft tissue stripes converging on the esophageal hiatus of the diaphragm. A fluid filled dilated esophagus does not usually have radiographically discrete margins and appears as an increased opacity in the caudodorsal thorax on the lateral film. A VD or DV view confirms the increased opacity is on midline and prevents confusion with pulmonary pathology. Sharpei breeds will have a redundant esophagus at the thoracic inlet that can be seen without clinical signs and thereby the clinical significance of this finding is not known.

Is the esophagus dilated? It is important to distinguish segmental from generalized megaesophagus. Dilation of the esophagus cranial to the heart base in immature animals is consistent with a vascular ring anomaly or a cranial/middle mediastinal esophageal stricture**.** Acquired segmental megaesophagus is rare but may occur as the result of esophageal stricture formation or secondary to a focal partial obstruction (foreign body or mass). Generalized megaesophagus is diagnosed if the entire esophagus is dilated. It may be congenital or acquired. The list of causes of acquired megaesophagus is too numerous to mention here and the reader is referred to textbooks of small animal medicine for the appropriate work up of dysphagia and regurgitation. Several common causes of acquired generalized megaesophagus may be due to myasthenia gravis, neuromuscular disorders, and primary esophageal disorders (esophagitis, diverticulum or partial/complete obstruction), acetylcholinesterase inhibitors (organophosphate toxicity) or endocrinopathies but is commonly idiopathic. Megaesophagus is often accompanied by aspiration pneumonia that is sometimes best-evaluated using right and left lateral radiographs. Careful inspection of the lung parenchyma over the cardiac silhouette is required to visualize the presence of parenchymal abnormalities. However, animals with severe pulmonary disease and dyspnea may exhibit esophageal dilation due

to aerophagia, so the presence of esophageal disease can only be accurately assessed when the dyspnea has resolved.

Is there an esophageal foreign body? Is the esophagus perforated? Esophageal foreign bodies are more commonly seen in dogs and only rarely in cats. The common sites for objects to become trapped are the thoracic inlet, heart base and esophageal hiatus. In cats foreign bodies may also become trapped at the cricopharyngeal sphincter. Bones are easy to identify but soft tissue opaque objects (cloth material, rubber material) are often overlooked. This is especially true as owners can confuse vomiting with regurgitation thereby directing the clinician's attention to the abdomen. The esophagus is usually dilated cranial to the lesions and gas may outline the foreign object. The mediastinum should be carefully evaluated for evidence of an esophageal perforation. Perforation results in a mediastinitis that is seen as a peri-esophageal accumulation of fluid and mediastinal gas. This may progress to pleural effusion and a pneumothorax.

Is there an esophageal mass? An esophageal mass effect can be seen with foreign bodies, parasitic granulomas or primary esophageal tumors. Differentiation may not be able to be done without an appropriate contrast medium study (esophagram) using a barium sulfate paste, liquid and barium sulfate mixed with food. Esophageal tumors are rare, but can occur. Squamous cell carcinomas and leiomyomas are the more tumors of the esophagus. A tumor can be present at the gastroesophageal junction and may not be seen unless fluoroscopy is used to dynamically evaluate this area. Parasitic granulomas secondary to *Spirocerca lupi* will be seen in the mid thoracic esophagus. These parasites are rare in the United States. Any esophageal mass can cause hypertrophic osteopathy with resulting palisading periosteal reactions along the diaphyses of long bones. The original presentation in these dogs is because of the limb swelling and lameness.

Trachea

Is the trachea normal? The caudal cervical trachea is usually included on a lateral thoracic radiograph. The trachea can be seen as the radiolucent (gas filled) tube extending from the caudal cervical region through the thoracic inlet and in a dorsal 2/3 position within the cranial thorax. The trachea terminates at the carina, which is the bifurcation of the caudal thoracic trachea into the caudal principal bronchi. The normal trachea at the thoracic inlet is between 15 and 20% of the thoracic inlet internal dimension as measured on the lateral radiograph. For bulldogs and other brachycephalic breeds this measurement can approach 12% and still be considered normal.

Is the size of the trachea narrow (small luminal diameter)? If the trachea is narrowed is the lesion focal, generalized, fixed or dynamic? A hypoplastic trachea will be seen throughout the length of the cervical and thoracic trachea. A hypoplastic trachea exists if the measured luminal diameter is less than 12% of the thoracic inlet internal measured dimension. Typically dogs with hypoplastic tracheas will present early in life and will have other components of a brachycephalic syndrome.

If a clinical suspicion of tracheal disease exists radiographs of the entire trachea should be obtained during inspiration and expiration. Tracheal collapse is a common clinical entity in small and toy breed dogs**)**. Incompletely formed tracheal rings and a flaccid or redundant tracheal membrane cause narrowing of the lumen. This is usually a dynamic lesion that is it changes with the phase of respiration. On inspiration there is negative pressure within the cervical portion of the trachea and it will collapse or narrow. On expiration, positive pressure within the thorax causes narrowing or collapse of the intrathoracic trachea and in some cases the main stem bronchi. Uniform narrowing of the tracheal lumen is seen in tracheal hypoplasia, especially in brachycephalic breeds. Apparent uniform narrowing of the trachea may be seen in dogs due to hemorrhage caused by intoxication by vitamin K antagonist rodenticides. In these cases, the air shadow of the lumen will be much smaller than the outline of the tracheal rings. A focal fixed narrowing of the trachea is most likely a post-traumatic stricture. These are usually located at or just caudal to the thoracic inlet. These lesions are easily overlooked as they are small and may be partly obscured by the overlying shoulder musculature. The stenosis is the result of a traumatic tear of the trachea or overenthusiastic inflation of the cuff of an endotracheal tube.

Is there a mass or nodules within the trachea? Is there a foreign body present? Occasionally tumors arise from the tracheal mucosa and result in mass or nodule formation. Multiple nodules located at the tracheal bifurcation are caused by infestation with the filarial nematode, *Osleris osleri*. Tracheal foreign bodies are rare. Mineral opacity or metallic objects are easy to detect but fragment of wood or leaves are more common and being soft tissue opacity are more difficult to detect.

Is the trachea displaced (mass effect resulting in tracheal displacement)?

Displacement of the tracheal is a very useful radiographic sign. Dorsal displacement of the cranial thoracic trachea occurs as a result of a cranial mediastinal mass. Keep in mind this appearance can be seen in some dogs, especially if the head is tucked down when the radiograph is taken. Before concluding a mass is present the cranial mediastinum should be evaluated on both radiographic views. Also repeating the lateral radiograph with the dog's neck in an extended position will confirm that the apparent dorsal deviation was secondary to neck flexion (positional) and not a true mediastinal mass. In young dogs with a persistent right aortic arch or other vascular ring anomalies will result in ventral deviation of the trachea on the lateral radiograph. On the VD radiograph the trachea will be displaced toward the left side and can be seen to the left of the vertebrae at the thoracic inlet. A heart bass mass may cause dorsal and rightward displacement of the distal trachea while generalized cardiomegaly causes dorsal displacement of the trachea.

Ventral displacement of the trachea at the level of the carina on the lateral radiograph is usually secondary to either tracheobronchial lymph node enlargement or a dorsal and central pulmonary or mediastinal massThere are three primary lymph centers associated with the tracheobronchial lymph nodes. Depending on the abnormality, there is one or more of these lymph nodes that will enlarge. The right tracheobronchial lymph node is located between the right cranial lobe bronchus and the trachea. Enlargement of this lymph node will cause lateral and ventral displacement of the right cranial lobar bronchus. The central tracheobronchial lymph node is located between the right and left caudal principal bronchi just caudal to the carina. There will be ventral displacement of the carina and caudal principal airways as well as widening of the caudal principal bronchi when the central tracheobronchial lymph node is enlarged. The left tracheobronchial lymph node is located between the cranial sub-segmental bronchus of the left cranial lung lobe and the trachea. Enlargement of this bronchus will cause ventral and lateral displacement of the associated left cranial lung lobe bronchus. Tracheal displacement is not a reliable radiographic sign if a moderate or large volume of pleural fluid is present. The trachea can appear to be dorsally and caudally displaced in this situation and a cranial mediastinal mass can neither be denied nor confirmed. As previously mentioned, erect, horizontal beam radiographs after thoracocentesis may help define the presence of any cranial mediastinal abnormalities.

Pulmonary masses can displace the trachea and principal airways in any direction depending on the anatomic origin and size of the pulmonary mass. Evaluation of the bronchi for possible mass invasion should be done, as bronchoscopy may then be beneficial for obtaining a diagnosis.

Major bronchi

Are the bronchi normal? The major bronchi have walls that are thick enough to be radiographically visible and should not be mistaken for an abnormal bronchial pattern. Each bronchus should be carefully evaluated for evidence of narrowing, enlargement, foreign bodies or displacement. One has to be familiar with the normal bronchial anatomy and origin of each bronchus from the trachea for accurate interpretation. Straight lateral radiographs are required for best evaluation of the lobar bronchi. Lobar bronchi can be typically seen to the level of the second and third generation. Linear mineralizations can be seen within the walls of the trachea and principal airways in older geriatric dogs and considered normal. Dystrophic mineralization of the tracheal rings is also an inconsistent finding that is considered normal. This change can also be seen in dogs that have pituitary dependent hyperadrenocorticism. As the bronchi move away from the central trachea, the airways will narrow or converge into the periphery. At times the only indication of where the bronchus is located may be because of the location of the pulmonary artery and vein.

Are the bronchi narrowed? Collapse of the principal bronchi during expiration is common in dogs with tracheal collapse. This is an important finding as bronchial collapse is not amenable to surgical correction. In some cases collapse of the bronchi can only be demonstrated by fluoroscopy.

Are the bronchi enlarged? Bronchiectasis is defined as the chronic, abnormal dilation of the bronchi or bronchioles as a sequela of inflammatory lung disease of chronic obstructions associated with pneumonia and heavy mucous secretions. These changes are commonly associated with bronchopneumonia or recurrent lung infections as the ciliary apparatus of the bronchi and trachea is normally abnormal as well. A dilated bronchus can be seen into a lobe that has acute pneumonia, but returns to normal after treatment. In true bronchiectasis, the diameter of the bronchi will not return to normal and in fact may get larger over time. The different types of bronchiectasis include saccular, cylindrical (tubular) or a mixture of both. These are just anatomic descriptions as to what the abnormally dilated

airways look like on radiographs and have nothing to do with the underlying pathophysiology of the disease process. At times the saccular form may appear like a cavitated lung lesion and horizontal beam, sternal recumbency radiographs may be necessary in order to differentiate between these two different radiographic lesions. In young dogs with recurrent infections, hereditary disorders of the ciliary apparatus (ciliary dyskinesis) should be evaluated for using electron microscopy or nuclear medicine studies that are specific for ciliary clearance.

Are the bronchi displaced? Displacement of the principal bronchi indicates enlargement of adjacent structures. Left atrial enlargement causes dorsal displacement of the left caudal lobar bronchus and rather than both bronchi being superimposed the bronchi are split on the lateral film. Severe enlargement will cause dorsal displacement of the right caudal lobar bronchus too. On the VD or DV film the caudal lobar bronchi are displaced laterally, resulting in a stirrup like appearance also described as the bowlegged cowboy. Enlargement of the left atrium is most often caused by mitral endocardiosis or dilated cardiomyopathy (DCM) in dogs and hypertrophic cardiomyopathy (HCM) in cats. Similar lateral displacement of the bronchi is seen with tracheobronchial lymph node enlargement. However on the lateral film, enlargement of these lymph nodes causes ventral displacement of the principal bronchi. Common causes of tracheobronchial lymph node enlargement include lymphoma, metastasis from primary pulmonary neoplasia, malignant histiocytosis or systemic mycosis.

The Middle Mediastinum.

The Cardiac Silhouette

Depending upon the cardiac abnormality radiology can be both highly sensitive and specific in diagnosing specific cardiac disorders. However, radiology can also be extremely insensitive and non-specific for other cardiac disorders. This may seem contradictory but keep in mind that we cannot see internal cardiac chambers, vessels, leaflets, etc. We can, however, extrapolate specific changes in the cardiac chambers from relatively non-specific changes in the overall size and shape of the heart. Radiology is most limited in the diagnosis of congenital heart disease and more useful for evaluating acquired cardiac disease. Although a disease specific diagnosis may not be made, valuable information about the severity of cardiac changes, degree of heart failure and response to therapy can be obtained from radiographs. Serial radiographic examinations over time can also document progression of cardiac changes, chamber enlargement and heart failure.

The Caudal Mediastinum.

Abnormalities of the caudal mediastinum have been covered in the section of the esophagus. Several gastro-esophageal abnormalities should be mentioned however. This includes paraesophageal hernias, hiatal or sliding esophageal hernia and a gastroesophageal intussusception, **(Figure 87)**. These abnormalities can be seen as discrete soft tissue mass effect in the caudal esophagus with widening of the caudal mediastinum being present on the VD radiograph. Left lateral radiographs will aid in documenting a sliding hernia more readily than the right lateral radiograph. The Sharpei breed is predisposed to gastroesophageal hernias. Gastro-esophageal intussusceptions are rare and are characterized by a soft tissue and gas filled mass in the caudal esophagus. Gastric rugal folds in the esophagus can be identified characteristic of this abnormality. As with other esophageal disorders, aspiration pneumonia can be present. Esophageal masses can be located at the gastroesophageal junction. Caudodorsal mediastinal masses can originate in and around any of the soft tissues of the caudal mediastinum. These tumors are rare in the dog and cat.

The Lungs

As the final part of the paradigm, the lungs should be evaluated. This is often the most difficult in the eyes of those who feel a bit intimidated by thoracic radiography.

The easiest way to evaluate the pulmonary parenchyma is based on peak inspiratory films. Table 1 summarizes the radiographic features of pulmonary patterns. The initial step is to evaluate the overall opacity of the lung. Are the lungs increased or decreased in opacity? If the lung(s) are ***generally*** radiolucent then the most common reason is hypovolemia from any cause, followed by hyperinflation. Causes of ***focal*** radiolucencies would include: pulmonary bulla, blebs, cavitated lesions (granulomas or tumors), pneumatocoeles and pulmonary thrombo-

embolism involving a specific lung lobe. With increases in pulmonary opacity, one must assess the vessels. Are the vessels visible but ill-defined, or are they completely obliterated? Answering this question defines the presence of an interstitial or alveolar pattern, respectively. It is important to note that differentiating between the unstructured interstitial and alveolar patterns helps determine severity of disease.

Increased pulmonary opacity may also be more closely associated with the bronchi. If the increase opacity is closely related to the airways, and is caused by soft tissue opaque lines and rings, this is compatible with a bronchial pattern. Bronchial patterns are most commonly associated with airway disease from infectious, inflammatory or infectious etiologies. However, remember that the vessels and lymphatics are located nearby, and disease of these structures (hemorrhage, edema, metastases) may artifactually produce the impression of a bronchial pattern.

Alternatively, the increased pulmonary opacity may actually result from the vessels. If the vessels are enlarged, this can contribute to the overall opacity of the lungs. The vessels will be large, but may be well defined, resulting in a vascular pattern.

It is important to remember that most pulmonary disease results in a mixed pattern. This is reflective of the fact that our attempt to characterize pulmonary pathology with radiographic patterns is a contrived system, and that many diseases result in multiple changes. For example, left-sided congestive heart failure may result in both a vascular pattern, unstructured interstitial pattern, and/or an alveolar pattern. Pneumonia may result in a structured interstitial pattern (fungal), unstructured interstitial or alveolar (bacterial/aspiration) and may have a bronchial component.

When assessing the meaning of pulmonary patterns, location of the change has the greatest influence on the differential diagnosis list. Describe the anatomic location of the abnormality including lung lobes involved and if there is partial lobar involvement. Next, is there a contralateral or ipsilateral mediastinal shift noted on the VD/DV image (assuming the VD/DV image is straight and the sternum is superimposed over the thoracic vertebrae)? In general, a cranioventrally distributed unstructured interstitial pattern or alveolar pattern is suggestive of pneumonia. A caudodorsally distributed unstructured interstitial pattern or alveolar pattern is suggestive of pulmonary edema. In these cases, the recognition of an unstructured interstitial vs. alveolar pattern distinguishes the severity of the disease, whereas the location helps us distinguish between etiologies.

The caveats for lung patterns are:

a. The pulmonary pattern will not correlate to a pathognomonic histological diagnoses. Pulmonary patterns are often mixed for a given disease. Decide what pattern is dominant.

b. The pulmonary pattern may represent a disease in transition (interstitial to alveolar or vice versa).
c. While the term broncho-interstitial is descriptive of the fact that patterns are often mixed, this term is not always helpful. This is not to say that a disease process (e.g., heartworm disease or PIE) cannot have both a bronchial and interstitial component, but again broncho-interstitial is not a category to look up in a table in a book on radiology. You will have to decide whether or not the predominant pattern is bronchial or interstitial in order to sort through a justified, prioritized differential list.

Table 1. Radiographic Features of Pulmonary Patterns

Pattern Name	Radiographic Features	Comments	Disease examples (not all inclusive)
Alveolar	Lobar sign; Uniform soft tissue opacity; Air bronchograms; Will not see pulmonary vessels or airways; Border	Location is important for formulating a differential list; Is the easiest pulmonary pattern to recognize.	Aspiration pneumonia; Bronchopneumonia; cardiogenic and non-cardiogenic pulmonary edema; neoplasia;

	effacement of heart or diaphragm.		hemorrhage; smoke inhalation; etc.
Bronchial	Rings and lines are noted within the pulmonary parenchyma; look in the periphery and away from the pulmonary hilum.	Usually generalized; be sure to evaluate in the peripheral lung fields and in the thin areas of lung.	Chronic bronchitis; pulmonary eosinophilic pneumonopathy; heartworm disease; allergic lung disease; feline asthma
Vascular	Increased in size of the pulmonary arteries, veins or both (left to right shunting lesions).	Added lung opacity is secondary to enlargement of the pulmonary vessels.	Pulmonary arteries – heartworm disease or cor pulmonale; Pulmonary veins – left heart failure; Both – left to right PDA, VSD, ASD or over circulation secondary to volume overload.
Structured Interstitial – nodules or miliary pattern.	Multiple "millet seeds" or small miliary nodules noted throughout the lung fields; variably sized pulmonary nodules.	Usually needs to be at least 5 mm in size to be seen as a distinct nodule; Fake-outs include nipples, end-on vessels and pulmonary osteomas.	Lymphoma, disseminated neoplasia (carcinoma) and fungal disease. Parasitic, eosinophilic or pyogranulomatous pneumonias. Nodules can be cavitated.
Unstructured Interstitial	Increased opacity to the lung fields with decreased visualization of the pulmonary vessels, aorta and caudal vena cava.	Typically generalized and never mild!	Exposure, exposure, expiration, expiration, lymphoma, fibrosis, fungal infection, edema, hemorrhage, infectious etiologies (viral, bacterial), eosinophilic pneumonopathy.

Summary

1) Technical factors are of utmost importance for diagnostic quality image. Always begin with a diagnostic image
2) A systematic, organized and repeatable approach to radiographic interpretation is the cornerstone of success in diagnostic imaging
3) Begin with the extrathoracic and pleural structures before being lured into the thoracic cavity
4) Pulmonary abnormalities should be described in terms of anatomic localization as well as a pulmonary pattern description, which is sometimes less important
5)

Suggested Reading/References

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TO CUT OR NOT TO CUT: RADIOGRAPHIC EVALUATION OF MECHANICAL OBSTRUCTION

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Introduction

Successful interpretation begins with a diagnostic quality radiograph. Technique and positioning must be adequate; alterations in positioning result in odd shapes and abnormal superimposition, making the distinction between normal and abnormal difficult.

Knowledge of anatomy cannot be over-emphasized. Knowledge of normal radiographic anatomy is a fundamental building block of interpretation, and will serve as a foundation for continued success. Documenting abnormalities in anatomy (findings) is the basic function of interpretation, and recognizing them is an acquired skill.

Evaluation and synthesis are the final steps in completing your interpretation. Evaluate your findings for their value. Is the finding incidental, or does it have a high sensitivity or specificity for a disease process? The value of a finding may be low by itself, but when added to your additional findings may form a pattern of a disease or specific subset of diseases—your differential diagnosis. Synthesis, then, is putting it all together and recognizing that pattern. How do the findings relate to pathophysiology? What pieces of the puzzle do I have?

Once you've recognized the pattern and generated a prioritized list of differential diagnoses, you can proceed with the case. What is your next step? Is it another diagnostic test or is it a therapeutic plan?

Objectives

1. Review of interpretive principles with a specific focus on gastrointestinal radiography
2. List radiographic tests that can be used to help diagnose obstruction
3. Discuss the value of each of these tests, and the value of using tests in series

4. Implement radiographic tests that are useful in diagnosis of gastrointestinal obstruction
5. Interpret radiographic tests in the context of clinical findings

Image Quality

Have you ever heard the phrase "garbage in, garbage out"? If you pulled a serum chemistry panel, and let it sit in the hot sun for 2 days, would you run it and expect accurate results?

Radiography is no different. If your technique and positioning are poor, the accuracy of your test decreases. The increased availability of digital radiography brings with it precise veterinary algorithms and post-processing adjustments that virtually eliminate the need for retakes due to over- or under-exposure. The rapid production of digital images decreases the time needed for a retake, making retakes due to poor positioning faster. With this technology, there is no need to take a poor quality image!

If film-screen radiography is your preferred medium, be sure your technique chart is accurate for extremity, abdomen, and thorax. Maintain your screens in good working condition, without scratches or dirt. Be sure your processor is properly functioning, with adequate replenishment.

Orthogonal projections are required. The single lateral projection is not a complete study, and can mislead you, sometimes to the patient's detriment. Always perform a complete radiographic examination.

Positioning

For a lateral projection the pelvic limbs should be caudally extended, and the x-ray beam should extend from the cranial aspect of the xyphoid to the coxofemoral joints. Liberal use of the collimator should be employed to reduce the field of view to only that needed for thoracic radiography. Typically right lateral and ventrodorsal projections are obtained.

Abdominal radiography is a technical challenge as there is little contrast between the soft tissue structures of the peritoneal and retroperitoneal spaces. Contrast is maximized with low kVp and high mAs techniques.

Anatomy and Systematic Review

Body Condition and Serosal Detail

The first step in interpretation is assessment of extraabdominal structures, the patient's body habitus, and the presence of intraabdominal fat. Intraabdominal fat is the primary source of contrast in the abdomen as differences in atomic number allow differential absorption of x-rays, generating contrast (photoelectric effect). Age is an important consideration in this assessment, as young patients may have little intraabdominal fat normally. The retroperitineal space contains the kidneys, the ureters, the adrenal glands, and several lymph nodes. The peritoneal space is separate, and contains the remainder of the abdominal organs.

Gastrointestinal tract

The canine stomach lies transversely across the abdomen. The fundus is located to the left of midline and dorsal, the body is located on midline and ventral, and the pylorus is located to the right of midline, midway between the dorsal and ventral border of the abdomen. The position of the patient for radiography will dictate where fluid (dependent) and gas (non-dependent) will be present. On a right lateral projection the fundus contains gas, and the pylorus contains fluid. The pylorus can be mistaken for a round, soft tissue mass on a right lateral projection. On left lateral projections, however, the pylorus often contains gas, confirming that this is not a mass but a hollow viscus. Positional radiography is also often important in highlighting gastric wall masses, especially if contrast procedures are being performed. In the feline patient, the entirety of the stomach is located to the left of midline on the ventrodorsal projection, with the pyloroduodenal junction located on midline.

The descending duodenum runs caudally along the right side of the abdomen on a ventrodorsal projection and is located about midway between dorsal and ventral abdominal borders on the lateral projection. The duodenum is typically fluid filled, but may occasionally contain gas. The presence of gas in the descending duodenum has been associated with pancreatitis; however, this can be an indicator of other regional inflammation, or may be normal.

The small intestinal tract fills the mid abdomen and seen as multiple, curvilinear soft tissue loops that contain variable amounts of gas in the canine patient. The intestines often have a variable diameter, usually indicating a normal degree of peristalsis and segmentation. The most common cause for gas in the intestinal tract of the canine patient is aerophagia. In the feline patient, very little gas should be present in the intestinal lumen, and in more obese feline patients, the jejunal segments are often found in the right mid-abdomen. This should not be confused with the bunching often seen with plication associated with a linear foreign body.

Intestinal diameter should not exceed 12 mm from serosal margin to serosal margin in the feline patient; in the canine patient, intestinal diameter as a rule of thumb should not exceed 1.6 times the height of the body of L5 centrally on a lateral projection.

Intestinal distention, once identified, can be further characterized by its distribution. Focal distention involving a segment or segments of bowel typically indicates mechanical obstruction. This is often described as the presence of two different populations of small intestinal segments (normal and distended). Differentials for obstructive/mechanical ileus include luminal disease (foreign body, intussusception), mural disease (intestinal neoplasia, infection), or extramural (intestinal torsion, infarction). The presence diffuse distention, involving the majority, if not the entirety of the small intestines, typically indicates a functional abnormality. Differentials for functional ileus generally include toxins, metabolic diseases, neurologic disease, inflammation (peritonitis) or possibly distal (ileal) obstruction.

The large intestine and cecum are relatively fixed in position. The canine cecum is typically gas filled and located to the right of midline on a ventrodorsal radiograph, midway between dorsal and ventral on a lateral radiograph. It is usually “C” shaped, and is in close proximity to the descending duodenum and right limb of the pancreas. A gas filled cecum is not typically seen in the feline patient.

The ascending colon is short, extending cranially to the right colic flexure where it becomes the transverse colon. The transverse colon is located caudal to the stomach, and is in close proximity to the left limb of the pancreas. It continues across midline to the left colic flexure, where it turns caudally and

becomes the descending colon. The descending colon continues caudally along the left abdomen, relatively dorsal in position, becoming the rectum at the level of the pelvis.

Pancreas

The canine pancreas is normally not visible. Abnormalities in pancreatic size may cause displacement of surrounding organs. In obese cats, the left limb of the pancreas may be visible in the triangle of fat surrounded by the gastric fundus, the spleen and the left kidney.

Interpretive Principles

Roentgen Signs

Fundamentally, image interpretation is based on thorough evaluation of ***location***, ***size***, ***shape***, ***number*** and ***opacity***. Evaluation of *location* refers not only to changes in organ location but also *lesion location and distribution* (*focal, multifocal, diffuse*). Determination of *size* is, in some cases, subjective, but objective measurements for some organs have been published. *Shape, contour and margination* of an organ or structure is also important in evaluation of pathology (*rounded, irregular, smooth*). While *number* of organs is relatively constant, the number of lesions (one, two, multiple) along with their *distribution* can be used in concert to arrive at a more narrow list of differentials. Most tissues in the abdomen will have *soft tissue opacity*. Relative differences in the soft tissue opacity of organs are often related to physical density, or thickness. *Fat* opacity is responsible for the contrast available in the abdominal cavity.

The basis for interpretation is recognizing when an organ deviates from its expected normal appearance. Roentgen signs provide an organized, systematic method to evaluate an organ for normalcy, and to decide exactly how it has become abnormal.

Mass effect

The term “mass effect” relates to those cases where displacement of organs is noted, but a discreet mass is not identified. Therefore, radiographic effects of a mass are noted, but the mass itself cannot be located.

The location of a mass is paramount in interpretation of abdominal radiography. Once the location (Roentgen Sign!) can be ascertained, a limited number of organs can be implicated as the source of the mass.

Border Effacement

When two structures of the same opacity are in contact with one another, their margins cannot be ascertained. This is a cardinal principle of radiology, and is a concept that is often used in interpretation.

Mechanical Obstruction

How do we apply these principles to diagnose mechanical obstruction? This is a challenge. Several rubrics exist to help clinicians determine whether or not an animal requires surgery, or whether tincture and time will suffice. Most of these are focused on the size of small intestinal loops, and clearly require

that the large and small intestines can be distinguished. Secondly, there need to be requirements for the distinction between distended and non-distended bowel. Finally, we would like to conclude that there are 2 populations of bowel; those that are distended, and those that are not.

Methods to distinguish between distended or dilated bowel and normal bowel have been described. Perhaps the one with which clinicians are most familiar is the comparison of jejunal diameter, measured from serosa to serosa, to the height of the mid body of L5. More recently, a group has suggested that a comparison between the maximum and minimum intestinal diameter may yield more accurate diagnoses. A maximal small intestinal diameter to mid body of L5 ratio of 2.4, a maximum small intestinal diameter to minimum small intestinal diameter ratio of greater than 3.4, and a maximal small intestinal diameter to average small intestinal diameter ratio of greater than 1.9 are compatible with mechanical obstruction. It is important to understand that each of these tests for mechanical obstruction is designed to aid the clinician in differentiating 2 distinct populations of bowel; a normal population and a distended population. This concept is important, as we are using the existence of 2 populations of bowel – normal and abnormal – to conclude that mechanical obstruction is present.

Size matters, but it is not the only feature that is used to document abnormal intestinal segments. Abnormal contents, abrupt turns (hairpin turns), and stacking (the presence of two or more segments that are oriented parallel to one another), may also signal that obstruction is present.

Dealing with equivocal radiographic findings can be a clinical challenge. Recently, the value of follow up radiographs in the diagnosis of mechanical obstruction has been questioned. In general, follow up abdominal radiography in cases that are deemed equivocal for mechanical obstruction often does not provide increased accuracy. However, for experienced radiologists, follow up radiographs may be useful in ultimately concluding about mechanical obstruction. In addition, it has been suggested that intestinal dilation, once identified, does not resolve frequently on follow up radiography. This may call into question the effectiveness of medical management in some cases of mechanical obstruction. More research needs to be done on this topic.

Finally, it is important to interpret these findings in the context of clinical signs. Especially in the context of a linear foreign body, or in other cases where pathologic distention is questionable, and the distribution of the intestinal segments is thought to be normal, clinical findings of moderate to severe abdominal pain and/or intractable vomiting can be valuable when considering the final conclusion of mechanical obstruction. **The decision to go to surgery is complex, and is based on not only the radiographic findings, but also clinical acumen.**

Once a diagnosis of obstruction has been made, differentials can be divided into those that affect the lumen, the wall, or outside of the wall to create dilation. Luminal diseases causing obstruction include foreign bodies and intussusceptions. Mural diseases causing obstruction include neoplasia (lymphoma, adenocarcinoma, etc.), or possibly infectious disease (pythium). Extramural diseases include vascular insult or intestinal volvulus.

The differentiation of these diseases is often challenging. Seeing a foreign body can be helpful, and if the patient has an accumulation of mineral or metal opaque material in the small intestine, a foreign body is very likely. However, accumulation of material can occur oral to (proximal) to mural lesions causing partial obstruction. Therefore, it is important to perform additional diagnostics to ascertain a more definitive diagnosis, especially in older patients in which neoplasia may be a likely differential.

Linear foreign bodies are difficult to diagnose radiographically. Most commonly, this radiographic diagnosis is made based upon abnormal distribution of the intestinal segments, with abnormal, abrupt changes in direction that result in a plicated appearance, with tear-drop or paisley shaped gas accumulations. In patients with poor serosal margin detail, this can be difficult to see. Ultrasound or an upper gastrointestinal series is often required for definitive diagnosis.

It is important to remember that, while ultrasound is an important part of the workup in a vomiting patient, radiographs and ultrasound work well in conjunction with one another, and should be used in series to better ascertain a diagnosis.

Summary

The material included in these proceedings is meant as a guide to the radiographic anatomy of the abdomen. The purpose of the session today is to apply principles of radiographic interpretation using a case discussion format, and to specifically apply them to cases of potentially obstructed patients. I hope you find it useful

These notes are in no way a complete discussion of abnormalities that may be encountered. The reader is referred to the Textbook of Veterinary Diagnostic Radiology (5th edition) for a more detailed explanation of radiographic abnormalities.

Ultrasound, Radiographs and CT of the Vomiting Patient

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Introduction

There are many indications for abdominal imaging in the veterinary patient. In the vomiting patient, abdominal radiography and abdominal ultrasound are commonly performed, especially in cases of potential gastrointestinal obstruction where surgery may be indicated. Abdominal radiography is an excellent screening test, readily available, inexpensive and rapid to perform. However, many radiographic findings can be non-specific, and the presence of moderate to severe peritoneal and retroperitoneal effusion can decrease the diagnostic value of abdominal radiography. Still, radiography can be very useful to distinguish functional vs. mechanical ileus in some patients, both of which can be associated with vomiting. This distinction is critical when deciding on surgical intervention.

Abdominal ultrasound (AUS) is a readily available, non-invasive cross sectional imaging modality that complements radiography. AUS has become more readily available and less expensive in veterinary medicine. With the increased availability of AUS, the role of abdominal radiography often comes into question. However, it is important to remember that there is a very direct relationship between the accuracy and value of AUS and operator experience. It requires years of experience to obtain and accurately interpret diagnostic AUS. There are multiple pitfalls and artifacts, therefore the advantages and disadvantages of this imaging modality when compared to abdominal radiography need to be completely understood. Prior to performing AUS, specific questions should be asked of the abdominal ultrasound examination based on the physical examination, clinical history and other laboratory data. In contrast to radiography, ultrasound can provide some information regarding motility, which can also be useful in differentiating functional vs. mechanical diseases. Ultrasound also allows the assessment of intestinal wall layering. Altered or effaced layering can be a feature of many diseases, especially neoplasia. In addition, assessment of the pancreas is also possible. Sonographic findings associated with pancreatitis have been described, thought the sensitivity of ultrasound for pancreatitis still remains approximately 65%.

Computed Tomography (CT) is another cross-sectional imaging modality that is steadily becoming more available in veterinary practice. CT uses x-rays to create thin slice images that, like AUS, eliminates superimposition. With ever increasing speed, spatial resolution, and the ability to create muliplanar reformatted images, CT can replace abdominal radiography and ultrasonography in some applications. The utility of CT in obstructive disease has been studied, and CT evaluation of the canine and feline pancreas is also possible.
For the purposes of this session, we will focus on the utility of radiography, ultrasound and computed tomography for the diagnosis of gastrointestinal obstruction in the vomiting patient.

Radiography

Radiography has long been the mainstay of diagnostic imaging. With the introduction and rapid advancement of digital imaging, radiography has become even more efficient, and allows a clinician to obtain opinions from radiologists, internists and surgeons with a few mouse clicks. Fundamentally, image interpretation is based on thorough evaluation of Roentgen signs: ***location***, ***size***, ***shape***, ***number*** and ***opacity***. Evaluation of *location* refers not only to changes in organ location but also *lesion location and distribution* (*focal, multifocal, diffuse*). Determination of *size* is, in some cases, subjective, but objective measurements for some organs have been published. *Shape, contour and margination* of an organ or structure are also important in evaluation of pathology (*rounded, irregular, smooth*). While *number* of organs is relatively constant, the number of lesions (one, two, multiple) along with their *distribution* can be used in concert to arrive at a more narrow list of differentials. Most tissues in the abdomen will have *soft tissue opacity*. Relative differences in the soft tissue opacity of organs are often related to physical density, or thickness. *Fat* opacity is responsible for the contrast available in the abdominal cavity. The basis for interpretation is recognizing when an organ deviates from its expected normal appearance. Roentgen signs provide an organized, systematic method to evaluate an organ for normalcy, and to decide exactly how it has become abnormal.

Evaluation of the gastrointestinal tract for evidence of mechanical obstruction has been extensively studied. The primary radiographic finding associated with GI obstruction is small intestinal dilation, which manifests as an increase in small intestinal diameter, and is commonly referred to as ileus. In the context of Roentgen signs, it is also important to evaluate the extent and distribution of small intestinal distention. The presence of focal or segmental ileus is most commonly associated with mechanical obstruction. Diffuse or generalized ileus is most commonly associated with functional disease.

The most commonly used tool for measurement of small intestinal diameter is the comparison of intestinal diameter to the height of the mid body of L5 on the lateral projection. Normal intestinal diameter should be no greater than 1.6 times the height of the mid body of L5. Intestinal diameter that is greater than this suggests the presence of ileus.[1] However, this imaging test can be associated with a significant number of false positive diagnoses of mechanical obstruction, and care must be used to interpret this finding in the context of other radiographic features that suggest mechanical obstruction. Additional radiographic features that should be assessed include the presence of sharp, hairpin turns (contour, shape); a gravel sign (opacity); and the distinct presence of two, discrete populations of bowel – normal diameter and abnormal diameter (distribution). More recently, it has been suggested that the ratio of largest small intestinal diameter to smallest small intestinal diameter should be used to more accurately assess for the presence of mechanical obstruction. A ratio of 2.4 or less is considered normal, while a ratio of 3.4 or greater is highly suggestive of mechanical obstruction.[2] Clearly this results in a wide grey zone that may be difficult to interpret. Therefore, it is still important to assess additional radiographic features that can assist in making a diagnosis of mechanical obstruction. Finally, when present, a well-visualized foreign body is always helpful! However, without evidence of obstruction (dilation/ileus), a foreign body may pass, and surgery may not be required.

Linear foreign bodies can be a challenging radiographic diagnosis. The position, location and distribution of small intestinal segments that contain a linear foreign body are frequently altered, classically resulting in GI plication. However, GI plication can be difficult to identify radiographically, resulting in many false negative diagnoses based solely on radiography. The

addition of positive contrast media or the use of alternative imaging such as ultrasound may help confirm this diagnosis.

Intestinal wall thickening is not reliably assessed with plain radiography. GI contents are soft tissue opaque, and border effaces the mucosal surface, leading to an erroneous observation that the GI wall is thickened. The administration of positive contrast media is required to identify the mucosal surface and to accurately diagnose mural thickening. Larger mural lesions can be detected as a mass, but it may not be possible to identify an intestinal mass lesion definitively, especially if there is concomitant peritoneal effusion.

Radiography can be an excellent test for the detection of free peritoneal gas. The identification of gas lucencies that cannot be reliably localized to the lumen of an intestinal segment is highly suggestive of free peritoneal gas. Additionally, the ability to visualize the peritoneal surface of the diaphragm, or the impression that serosal margin detail is increased can further support a conclusion of free peritoneal gas. Barring recent abdominal surgery or full-thickness body wall trauma, the primary differential diagnosis for free peritoneal gas is a ruptured hollow viscus. This can be a complication of a chronic foreign body or mural lesion.

Abdominal Ultrasonography (AUS)

Abdominal ultrasound (AUS) is often used to evaluate patients in which radiography is inconclusive or in cases where additional information regarding the possibility of neoplasia or pancreatitis may be desired. Where abdominal radiography provides contrast resolution that is limited to gas, fat, soft tissue, bone and metal, AUS provides a greater degree of contrast resolution that is based on acoustic impedance, which determines echogenicity. This increase in contrast resolution allows for discrimination of GI layers, and changes in acoustic impedance/echogenicity often accompany a multitude of disease processes. Many of these changes can be very non-specific, but when interpreted in conjunction with abdominal radiography and in the context of clinical history and suspicion, diagnostic accuracy increases.

The mucosal and the serosal margins of GI segments can be reliably identified and characterized using AUS. This allows resolution of both the wall and the lumen as separate, distinct regions. Luminal dilation of small intestinal segments <1.5 cm is a useful discriminatory finding for the diagnosis of moderate to severe distention. When this degree of intestinal distention is observed, a search for a cause of mechanical obstruction should be initiated.[3] Foreign bodies have a relatively characteristic appearance sonographically, showing a significant degree of distal acoustic shadowing and surface reflection that hints at their shape.[4,5]

Due to the aforementioned superior contrast resolution, mural lesions are identified better with AUS than with radiography. Assessment of intestinal wall thickness as well as the normal appearance, alteration or absence of intestinal layering can be accurately performed with ultrasound, and can provide insight into underlying etiology of mural lesions. In dogs, the presence of intestinal wall thickening and loss of layering is 50.1 times more likely to result from neoplasia than from enteritis.[6] Intestinal wall thickening and loss of layering can also be seen with oomycoses such as Pythium and Lagenidium.[7–9] The presence of gastric wall thickening along with pseudolayering is highly correlated with gastric epithelial neoplasia.[10] And gastric wall thickening in conjunction with concave mural defects and gas dissection is correlated with gastric ulceration.[11] Alterations in individual layer thickness and/or echogenicity can also be evaluated with AUS.[12–14] The presence of linear striations in the intestinal mucosa oriented perpendicular to the mucosal surface has been correlated with lacteal dilation in the dog. The presence of a mucosal stripe in cats has been associated with fibrosis, possibly related to

inflammatory bowel disease. And the identification of muscularis layer thickening in cats has been linked to the diagnosis of intestinal lymphoma.[13]
Ultrasound (US) is the most commonly performed diagnostic imaging test in cases of vomiting, and specifically in cases for which pancreatitis is considered the primary differential diagnosis. As a cross-sectional imaging modality with excellent contrast resolution as compared to radiography, US allows visualization of the pancreas in many cases. Because of the location of this organ between segments of the gastrointestinal tract that can often be gas filled, it can be challenging to image the pancreas completely. In these cases, focal pancreatic lesions can be missed.

Sonographic findings that support acute pancreatitis include focal effusion, hyperechoic fat, thickening of the pancreas with decreased pancreatic echogenicity, and regional ileus. Pancreatitis can occur the left limb or the right limb of the pancreas as well as the pancreatic body, an imaging findings should help localize the portion of the pancreas affected.

In an older study, the sensitivity for the US diagnosis of pancreatitis is reported to be approximately 68%. US technology has come a long way since the publication of that paper; updates on the sensitivity and specificity of US in the diagnosis of pancreatitis have not recently been investigated. However, it is important to point out that an important factor in the effective use of US in the diagnosis of pancreatitis is operator experience. US is very operator dependent, and as such, the results of this test can be markedly affected by sonographer experience. Additionally, not all animals with pancreatitis have sonographic abnormalities. Finally, the results of abdominal ultrasonography are also patient dependent. In smaller breed dogs, visualization of the pancreas is more easily performed, while for large breed dog, imaging of the pancreas can be more challenging. Therefore, it is important to combine tests from your diagnostic arsenal to arrive at the correct diagnosis.

Sonographic findings in cats with pancreatitis are similar to those identified in dogs, though occur with less frequency in cats with proven pancreatitis. Previously, dilation of the pancreatic duct was thought to be correlated with pancreatitis in cats; however, this progressive dilation has been postulated to occur with increasing age in feline patients, and does not directly correlate with pancreatitis.

The canine pancreas may also show increased echogenicity, which is often interpreted as areas of fibrosis, possibly indicative of prior, resolved pancreatitis. However, the sonographic appearance of the pancreas in dogs can be variable, and multifocal regions of increased echogenicity have been noted in healthy dogs with no reported prior history of pancreatitis. While proving the prior existence of pancreatitis in these populations may be difficult, this variability suggests that using focal increased pancreatic echogenicity as an indicator of prior pancreatitis may not be accurate.

In patients with peritoneal effusion, AUS will allow visualization of structures that cannot be seen with radiography. In fact, AUS can be indispensable in guiding sampling of effusion, and of abnormal organs. In addition, AUS has been reported to be accurate in identifying free peritoneal gas, and some consider it to be more sensitive than radiography.[15]

Computed Tomography

Recently, the utility of computed tomography (CT) in the evaluation of acute abdomen in dogs and cats has been reported with increasing frequency. While still in relative infancy for the diagnosis of intestinal obstruction, CT has been shown to be more accurate, faster and better for surgical planning compared to US in a population of dogs with suspected intestinal obstruction.[16,17] CT was as accurate as US in the identification of intestinal foreign bodies, with equal sensitivity and slightly lower specificity. In addition, CT has been show to more accurately identify the location of an intestinal lesion, and can be used to identify plication associated with linear foreign bodies. Further, depending on equipment, CT can be far more rapid, especially if performed under sedation. Due to the tremendous number of images created in a CT dataset, interpretation time can be increased, and when considered together, study and interpretation time for CT and US are similar.

Conclusion

The arsenal of imaging modalities available for imaging gastrointestinal disease is expanding. With advancements in technology, the cost of these modalities has decreased, availability has increased, and their utility in routine imaging of the vomiting patient has been demonstrated. Understanding the strengths and limitations of each in the context of clinical diagnosis is important to inform proper decision-making for your patient.

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Cathy Lund

CONNECTING WITH CAT OWNERS: WHY PAYING ATTENTION TO CATS MATTERS

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There are more than 95 million owned cats in the USA, and about 90 million dogs. Most of those dogs will receive some kind of veterinary care in their lifetimes, but for cats, the reality is dramatically different. In small animal practices, the statistics tell the story. Between 70-85% of visits in those practices are with dogs. Cats, and their owners, simply aren't coming through the doors. Or if they are, it is to get a kitten spayed or neutered, and then they're back again for end-of-life care. And because most cats aren't purchased by their owners—they are strays who become "adopted" over time--clients may not see these cats as having the same value or needs as an expensive Labradoodle.

From the perspective of extending care to cats, these are sobering numbers and should be concerning to all veterinarians. Why do so many cat owners not take their cats in for any sort of medical care?

We know it can be challenging to get cats to a veterinary office. Cats are difficult to get into carriers, and can be very vocal about their dislike of cars and transportation. When these cats arrive at your office covered in urine and feces, that ordeal certainly hasn't made clients feel enthusiastic about making another appointment.

We also know that the cost of veterinary care can be an obstacle to owners, who may not see the value in that care or question why bloodwork for the cat is the same cost as bloodwork for the dog. Cats adopted from shelters frequently are vaccinated and spayed or neutered, and the new adopters are left with the message that everything has been taken care of and the cat needs nothing further. Even a free first exam might not be enticing enough when there is no perceived need for it.

Another enormous impediment to getting these cats into practices is that cats are stereotyped as being self-sufficient, and take care of themselves. Couple this with a cat who stays in the house, and many cat owners simply do not understand why their cats need care at all. Cat owners frequently question why their inside cats need vaccines, since they believe the cats are not exposed to any risks. Owners of cats who stay indoors also may not understand how their cats might be exposed to allergens like pollens and develop asthma or skin conditions. Conversations about the value of preventive care like parasite control can hit similar roadblocks when clients are not convinced that their cats can benefit from these products.

And unfortunately, the problems don't stop there. If we do see a cat in for a visit, whether that is for vaccines or for some medical problem, and that cat and owner don't have a positive experience, then it is very unlikely that they will ever come back for additional care. And this doesn't mean that they will simply go to another veterinary practice—a negative experience frequently means that particular cat will not receive **any** veterinary care ever again.

From the cat and the cat owner perspective, first impressions definitely matter. What we do at the reception counter and in the exam room will make or break that experience, and the value of having a

calm, soothing, non-threatening, fear-free encounter is truly priceless. Cats who hiss and scream and urinate and cower are not having a positive experience, and that transfers over to their owners, who believe that the veterinary team is terrifying and torturing their beloved cat. We must recognize that handling should be gentle, and careful, sensitive attention to the cat's needs can encourage a partnership for better care. It's easy to underestimate the power that the words and actions of the practice team have on enhancing that experience for the cat and the owner.

Words matter. Veterinary practices have a language and a shorthand that can be somewhat universal, like taking the patient "to the back," and talking to each other about how that particular cat is "mean," or "bad," or "nasty," or "evil." We've all heard that, and we've even probably participated. But words will change the way we think, and it is very normal for people who think of a cat as being "bad" to not empathize with that cat and appreciate the fear and terror that is driving the aggressive behavior. This in turn will color the attitudes of co-workers in the practice and result in a uniformly combative and adversarial stance to any cat who is perceived as being one who resists exams and treatments. This will also trickle down to the clients, who will read the unspoken shorthand and body language and process that as exactly what it is: a perfunctory physical exam, a vaccine given to a scruffed and screaming cat who is then swiftly stuffed back into the carrier and quickly removed from the practice, with relief at the cat's exit clearly visible on the practice team's faces. This really doesn't encourage cat owners to come back for more.

It's vital that the veterinary staff understands why a particular cat is anxious and resistant, and takes the steps necessary to make that visit less confrontational. Cat behavior is rooted in their close proximity to their wild forebearers, and we will have a better idea about why cats act the way they do when we look at how they have evolved over the time since domestication.

Cats have remained relatively unchanged since they first started coming around human encampments, some 10,000 years ago. Cats were valued as mousers, and there was no need to enhance other traits since cats were already very proficient with rodent control. Cats evolved as solitary hunters and their very survival depended on their staying healthy enough to keep hunting. Because of this, cats need structure and a sense of control over their environment. They do not like change and they do not like anything unexpected. When they are sick or impaired, it affects their sense of control and causes stress, which is one reason so many cats hide signs of illness until they simply can no longer do so.

Cats have a complicated system of communications that are designed to minimize conflict. Cats who hiss and growl are sending out defensive signals that they want the other cat (or human!) to back away. It is not in the cat's best interests to fight and potentially become injured, because then that cat might be unable to hunt and could starve. Being able to read a cat's body language and other cues can help the team anticipate what might go wrong and head off any problems before they occur.

We've also got to appreciate what cats mean to their families. Cat owners can be just as quirky and individualistic as their feline companions, and they are equally as invested in feeling good about their caretaking skills as dog owners are. Labelling someone's beloved cat as "difficult" or "caution" doesn't tend to endear the practice team to owners. They are deeply attached to their little predators, and it is not in our best interest to cause them to feel embarrassed about their cat's behavior, such as asking, "Is he a good cat?" or acting like we've won a military battle when the vaccine finally goes in. If they see their cats being scruffed and forcefully restrained, and if their cats are yowling and screaming in distress, this completely undermines the bond we are trying to achieve. Clients want to be praised for taking care of their cats and they see themselves as the cat's parents and protectors. There is simply nothing worse for establishing that bond of trust and partnership with a client then what happens when they think we are effectively torturing their sweet and gentle cat.

Ultimately, the success of the veterinary visit will be in the eyes of the owner and their cat. Cats are not small dogs and they should not be handled like dogs. They preferentially like to be touched on the head and neck area, and they do not enjoy having their backs and sides vigorously rubbed. They want to feel in control and we need to allow them to acclimate to the smells and noises of a veterinary practice. It doesn't do a frightened cat any favors when their cat carrier is tipped upside down and they are dumped out like salt from a shaker.

When we invest in educating our staff about how to truly speak cat, and show them how to read a cat's body language and verbal cues, and when we make sure that gentle and respectful handing is the norm in our practices, cats will be more relaxed and easier to manage and examine. This will allow us to build a strong relationship with our clients that is grounded in trust, and this will enhance our ability to care for a woefully underserved pet demographic.

FIP: IS IT REALLY NO LONGER A DEATH SENTENCE?

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Coronaviruses are ubiquitous, and as we certainly know from our experience with the pandemic, they come in many shapes and forms. Cats get exposed to the enteric coronavirus from fecal shedding, and kittens can develop subclinical infections at around 8-10 weeks of age, and then shed virus for weeks to months. Once that shedding stops, the immunity it confers also stops, and that sets the stage for reinfections.

The virus has an affinity for the mature epithelial cells of the lower intestine, and kittens can produce IgM antibodies against coronavirus and also mount cell-mediated responses from birth. Passive transfer of IgG and IgA antibodies through the mother's milk protects kittens until their own immune systems mature. This virus is extremely widespread, and as viral shedding wanes, protection also decreases and recurrent infections happen frequently, especially in situations where cats are housed together and share litter boxes.

Feline Infectious Peritonitis, or FIP, is a mutation of the common enteric coronavirus. About 10% of cats infected with the intestinal-epithelial-infecting coronavirus will experience a viral mutation that drives the coronavirus from the intestinal epithelium into the peritoneal macrophages. These infections are unique to individual cats and tend to be strictly cell associated and confined to that cat, so cat to cat spread is very rare.

Not all cats whose coronaviruses mutate into the peritoneal macrophage version go on to develop FIP; in fact, only about 3-10% of those cats progress into the familiar and invariably fatal disease. Mortality rates tend to increase in dense, multi-cat environments, so cats from catteries, shelters and rescue groups are overrepresented. FIP is also a disease of younger cats: 95% of cases involve cats less than 7 years of age, and 70% of those cases occur in cats less than a year old. Because of the increased incidence rate in densely housed and physiologically stressful situations, cats from catteries have a three-fold increase in fatal infections. Male cats and purebred cats also appear to be slightly more likely to become infected and then develop FIP.

Pathophysiology

FIP can occur after peritoneal macrophages are infected by the virus. It is similar to other macrophage infections like tuberculosis, leprosy and deep mycosis. The disease process is mediated by the cytokine responses from the infected macrophages. Protective immunity can occur, but failure to establish it leads to the inflammatory response and disease associated with fulminant FIP. The time period between that initial macrophage infection to clinical disease can vary from days to months, and the actual disease course can also vary greatly. Some cats sicken and die within days, and far fewer (less than 5%) can have a disease progression that can extend for a year or more.

FIP has two common presentations: the effusive and non-effusive variations. The forms vary based on the relative balance of cellular and humoral immune responses seen in the infected cats. The effusive variation, or wet FIP, is characterized by an intense vasculitis and is the most common presentation of the disease. The non-effusive form, or dry FIP, preferentially selects out neurological tissue. Both forms of FIP are among the most common causes of feline neurological disease, such as seizure disorders, and in one study of nearly 300 cats with neurological problems, nearly 50% of those cats were diagnosed with FIP on histopathology. Cats who have wet FIP can switch their disease to the dry version, and vice versa, sometimes changing back and forth multiple times throughout the disease course.

EPIDEMIOLOGY

Stressful conditions dramatically impact virus shedding. The reservoirs of enteric coronavirus can easily mutate in crowded conditions, so reducing the environmental virus load is a critical factor in prevention. Because there is no durable immunity to enteric coronaviruses, the virus can reinfect cats and there is ample opportunity for mutations into the more virulent FIP to occur.

Decreasing crowding in shelters and catteries is imperative to decrease the risk of disease and lower viral shedding. Coronavirus shedding can increase by astronomical numbers when cats enter shelters, so developing foster programs at shelters that send kittens directly into private homes and bypass the shelter can be helpful in preventing disease. Allowing kittens to nurse and benefit from maternal Ab protection through milk is also useful, so early weaning might put kittens at greater risk of infection.

Purebred cats seem to have higher susceptibility to developing FIP and particular lineages within a breed can have higher infection rates, so there does appear to be a genetic component as to whether mutations develop.

DIAGNOSIS

For sick cats in a high-risk age bracket, the physical exam findings can frequently point to FIP. Wet versions of the disease have characteristic pleural and peritoneal effusions of sticky, yellowish fluid. Cats may be feverish, icteric, mentally dull and neurologically abnormal. Some cats have never fully developed and appear small for their age, and a recent stressful event, such as spaying or neutering or entering or leaving a shelter, can be a precipitating cause. Chorioretinitis and uveitis are other characteristic findings with FIP: the virus causes pyogranulomatous clumping that can be visible on the retina.

Lab work findings can also be helpful in making a diagnosis. Cats with FIP may have anemias of chronic disease, and often have a lymphopenia with a leukocytosis. High total protein levels are also suggestive of the disease. Cats typically have an increased globulin and decreased albumin levels, and a ratio of less than 0.6% is considered consistent with FIP, with the wet variation tending to have the lowest values. Bilirubin is also elevated in nearly half of patients, and this will occur without elevations in liver values. With the wet version of FIP, high protein levels in the fluid can be diagnostic. Typical antibody tests to coronaviruses cannot differentiate between the common enteric version and FIP, so many false positives occur. There are more sensitive RNA-based PCR tests available, but they are limited to the effusion sample and not blood tests, and the sample size must be large enough to enhance sensitivity. False negatives are common for this reason.

TREATMENT

The two questions I always hear from cat owners when their cat is diagnosed with this disease are: Is it contagious to my other cat, and will my cat be OK. For years and years we could reassure clients that the disease wasn't likely to spread from one cat to another, but that second question was much more difficult. FIP was effectively a death sentence, and even though we might have attempted various remedies, death was the invariable outcome. Most of the time we euthanized patients shortly after they had been diagnosed, and to see the grief these owners experienced was heart wrenching.

The mainstays of what were mostly palliative treatments were anti-inflammatories, and corticosteroids did appear to help some cats or at least lessen some of their decline. Antivirals and interferon were other treatment choices, but regardless of whether the clinician opted for homeopathic regimens or direct treatment, the end result didn't alter.

But, flash forward to 2019, and a drug has emerged that has transformed FIP from a fatal disease into something that is actually curable. This drug, GS-441524, is very, very similar to remdesivir, which has been given emergency FDA approval for use in the treatment of COVID-19 in humans. The company that manufactures remdesivir, Gilead Pharmaceuticals, had partnered with UC Davis before the pandemic and sponsored field trials to see whether GS-441524 could work against FIP, which it proved to be effective against in a spectacular fashion. A slightly different version of GS-441524, remdesivir, was simultaneously being studied as a treatment for Ebola in humans, which is not a coronavirus, and the drug ultimately didn't work well for that. But because Gilead didn't want any sorts of possible side effects in cats to potentially muddy the path for FDA approval for remdesivir, it declined to allow GS-441524 to be licensed in cats. When the pandemic emerged, remdesivir was singled out as an effective treatment for COVID-19, and the FDA granted it emergency use approval.

When Gilead opted not to pursue licensure for the cat FIP drug, pharmaceutical manufacturing entities in China began formulating GS-441524. The drug itself is apparently not too difficult to synthesize, and a large black market for this product soon appeared. FIP is also a growing problem in China itself, which is home to many purebred cats.

Initially, the use of this counterfeit formulation was quite controversial, and most efforts here in the US focused on pressuring Gilead to license their drug for animal use. This pressure hasn't resulted in any softening of the company's stance, and a Facebook Group FIP Rescue (previously called FIP Warriors) emerged as a kind of broker that connects the black market drug with desperate cat owners.

These treatments arrive in unlabeled drug vials, and owners are instructed to give 84 days of injections of an intensely painful product. The cost ranges between $5,000-$12,000 and the results are nothing short of miraculous. The vast majority of these sick and dying cats transform, and complete cures are much more common than treatment failures.

Whether this treatment will ever be legally available in the US is up in the air. If remdesivir receives full FDA approval beyond its current emergency use, then the drug could be used off-label for the treatment of FIP. It is likely that it will work the same way as GS-441524, but the study data on cats that would support that hasn't been done.

HOW TO MAKE YOUR PRACTICE PURR—FECT FOR CATS

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What's the most important thing about making your veterinary practice more welcoming to cats? You've got to be authentic. When you design with your own personality in mind, it will feel more natural to your clients, and they will positively respond to it. It also, very importantly, relaxes you and automatically creates comfort and a feeling of security, which will result in a calmer and more stress-free environment.

With cats, it is all about creating a quiet, calm, soothing and secure room. Be yourself when you decorate, but try to make your cat waiting area and exam rooms so peaceful and welcoming that they become a veritable oasis of serenity.

When your clients enter your building, it is helpful to have a vestibule space between the exterior door and the waiting room door. This is a safety feature for clients who do not bring their cats in carriers, or clients who immediately release their cats upon entering your practice.

Cat waiting areas really don't need to be big or luxurious. Your goal should be to get those cats and their owners into an exam room as quickly and seamlessly as possible. This is all about containing the cat and minimizing the stimulation he or she is experiencing. Cats react to noises and smells so while it is absolutely fine to have a cats-only area in your waiting room, it is very difficult to achieve a sense of security for the cat when they can hear and smell what is going on next door. The easiest way to minimize their stimulation is to get them into a secure exam room.

What cat owners experience matters, too. If we think about who loves cats, they are frequently quirky and enjoy feeling different. People who seek out cat practices like when their species obsession is mirrored by the practice: if you have a mixed practice you can still cater to the feline set by showcasing good design. If your cat-centric areas look like the dusty alcove where the prescription diets once lived, your clients will sense that and react accordingly. Respecting cat owners means recognizing what they respond to and making sure that your cat patients get as much love as your dog ones do.

What do cat owners dislike about general veterinary practices? They think that they and their cats are an afterthought, and the focus is all dog, dog, dog. They don't like it when their cats growl and hiss, and all of us know that is exactly what happens when a big and messy and out of control dog lunges to the front of a carrier and sticks his nose in the face of an already terrified cat. Cat owners also really don't like putting their cat carriers on the floor, either, so having another bench that they can place the carriers on top of helps them feel more like they are keeping their loved ones out of harm's way. Having a lower level of countertop at your reception area will provide a platform for carriers and greatly diminish your client's anxiety about keeping their cat safe while in the waiting area.

We know that exposure to natural lighting makes people feel better, and if you have the ability to have windows in your exam room, or transom windows that bring sunlight into exam rooms from the waiting area, it will help both the cats and the clients feel calmer. Keep in mind that if your windows overlook a

busy parking area, you should block off the lower sash with curtains or film so that visual stimulation is minimized but you still gain the benefit of natural lighting.

Cat exam rooms should be soundproofed, as should the treatment area or any rooms that noises can be expected from. We've all been in practices where the day begins with a very anxious and protesting cat, and we've seen how every single cat afterwards who enters the practice seems triggered to escalate. Some of this is a cat's natural defensive reaction to noises, and some of it is the lingering smell of fear pheromones. Both reactions can be mitigated with careful soundproofing and the liberal use of spray and plug-in pheromones like Feliway.

Another consideration when constructing cat rooms is to not use dropped ceilings. Stressed and anxious cats can and do jump into ceiling tiles, push them aside, and vanish into the rafters. If possible, a solid ceiling is much safer.

Paint color choices also have an impact, and even if the cat may not care if the room is green or violet, clients do, and if they are more relaxed because they aren't sitting in a room that combines red with chartreuse, that transfers to their cats. People have emotional reactions to colors and their combinations, so don't fall into the trap of painting everything white. Make things beautiful and your clients will respond accordingly. Good building materials also make an impact, and not using cheap moldings or hollow-core doors that scream cost cutting will resonate. You want to make a statement that you care about the environment that you are presenting, and that you take yourself and your practice seriously. What you do through your design choices will get noticed, even if subliminally, and help enhance the value of your veterinary care.

Exam rooms should be big enough to contain the cat and a few humans. Ideally, use solid benches for seating because cats will go beneath chairs or anything with openings for supports. Your technical staff will thank you for not having the ask the clients to stand up so they can move chairs to scoop up the cat. Exam tables should be cat-sized, and I am a big fan of natural surfaces. They are warmer and less clinical, and more in line with what cat owners appreciate. If you do have stainless steel exam tables, you can make cats happier by using heated towels to cover the table. Cats also very much like being in smaller protected areas with raised edges—this is why so many will sleep and stay in their litter boxes when in the hospital—so giving them a shallow box lined with a warm towel will sometimes be just the right touch to soothe a frazzled feline.

Good, original cat art on your walls will make a positive impression. There is a place for posters and tired veterinary images, but let's hope it is not in your office! Make sure that your artwork is sized appropriately for your room size. A 5X7 print will get lost in the middle of a wall that is 6 feet wide. Don't be afraid to use big, bold pieces. Hang your art securely so paintings don't move when rooms are in use or being cleaned, and be careful to have just the basics on your counters—cats can and will knock things down trying to find a place where they can feel secure. Our office has baby scales on the counter itself to take advantage of the tendency cats have to find that safe space. Cats are naturally drawn to structures with raised edges so they will frequently curl up on the scale and not anxiously patrol the counters.

Plants and art make people happy. People love seeing cared-for and lush plants in the waiting room area, and they can give your entire practice a serene and unique vibe. Uniformly framed beautiful images of cats displayed in the waiting area and exam rooms will make a wonderful statement. If you or one of your staff members is a photographer, get great close-up cat images. If you need to reach out to your clients for artwork, don't hesitate! Very little bonds a client to a veterinary practice more than their doctor displaying an image of that client's own cat! Have fun, and be creative. Your clients will respond to your efforts to make your practice more interesting than that clinical, sterile corporate entity up the

street. People really do notice when you pay attention to the details. What differentiates a fancy hotel from something more basic? It's that focus on the small touches that makes the entire experience smoother and more enjoyable. Ideally, your clients should come to your practice because it is so pleasant that they actually like to hang out in the waiting area and canoodle with your office cat.

Your goal should be to create an impact and deliver a special experience to your cat clients. Never be afraid to let your personality shine through, and when you successfully navigate that connection between clinical care and a fully-realized client experience, that is the groove where your cat-centered practice will flourish.

LITTER BOX LAPSES: HOW TO THINK OUTSIDE THE BOX SO YOUR CAT WON'T!

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Cats who do not use their litter box do not tend to fare well in most households. It is a devastating problem that negatively impacts the bond that people have with their cats. People relinquish their cats to shelters because of this behavior, and they are much less likely to ever own cats again. In fact, inappropriate urination is the number one reason cats are placed into shelters, and because people are ashamed about this, it is quite likely that these cats are labelled as being abandoned because of allergies or landlord issues.

Literally any advice you can give clients who are looking for help with this thorny problem will potentially result in them having a better relationship with their cat and not making the decision to abandon that cat. Cats will do better and people will too—and we know that people who own pets are healthier and happier than those who don't.

Why do cats use litter boxes? It is a learned behavior that kittens pick up from their moms when the kittens are around three weeks old. This is the age when substrate—or litter—preferences are formed. Cat litter mimics dirt, which most cats preferentially use, with an emphasis on the softer the better. If the mom was housed in a cattery, or someplace that uses substrates like shredded newspaper, the kittens will have a preference for that kind of material in their litter boxes.

Litter boxes and litter materials take advantage of what cats naturally want to do when they eliminate. There is no "litter training" that needs to take place with kittens and cats. We are simply taking advantage of their natural tendencies. And everything is fine when this works….

Feline inappropriate urination (FIU) is a very common problem in cats. It can be utterly simple to solve, or it can be enormously complicated. We also see cats who defecate outside the box. These are not nearly as common as our FIU cats, but there is overlap with FIU in that there are similar triggers and causes.

Cats who urinate outside the box are either spraying urine or squatting to eliminate. Most clients think all FIU is spraying, but that term is strictly limited to cats who back up against a surface like a wall and spray small amounts of urine while standing. This is also accompanied by a characteristic tail twitch. Squatting to eliminate is infinitely more common than spraying is, and those cats will squat and deposit a normal amount of urine on a substance that the cat finds suitable. These cats will frequently attempt to cover their eliminations, and most typically choose soft materials to eliminate on.

Both of these behaviors, including spraying, are equally distributed between the genders. They are also most frequently adult cat behaviors. Kittens who have FIU or FIE (feline inappropriate elimination) problems are almost always experiencing either a substrate preference issue or very commonly, a logistics problem with litter box location.

Most inappropriate elimination disorders occur in cats who are either spayed or neutered. There is a subset of marking behavior, primarily spraying, that is driven purely by sex hormones, and we see that with both males and females. Spaying or neutering stops this behavior easily 90% of the time.

Inappropriate elimination is always a behavior problem, but it doesn't always mean the cat is "crazy." An example of this would be what I frequently hear at my practice: "My cat was mad when I went on vacation so she peed on my bed." What I might think is, "Well, your roommate forgot to scoop the box when you were away so your cat decided to find another toilet option!" Or maybe the cat had some separation anxiety and was frightened without the owner being around.

Cats who have elimination disorders are not mad or angry or trying to punish their owners. That's us trying to make the cat act like a human and have human motivations. It's also us thinking that cats believe that their urine is revolting and disgusting. They do not think that! The pheromones present in urine can be deeply comforting to cats.

For most cats, the stimulus to inappropriately urinate is complicated. I frequently use the example of high school Geometry Venn Diagrams and talk with clients about how there are three main causes of this disorder but where those circles overlap can mean that cats might have more than one trigger. The three main categories I divide litter box disorders into are medical problems, litter hygiene or box issues, and true anxiety disorders, but it is also common that there can be overlap, such as when a cat who has a urinary tract infection also may have issues with where the box is located.

The basic approach to FIE is to make the box feel luxurious and wonderful and welcoming for the cat and to simultaneously make the areas the cat is using as box alternatives as unappealing and inaccessible as possible. Have your clients close that bedroom door, throw a tarp over the sofa, block off a window, and clean, clean, clean those contaminated sites. The smell can be a powerful attractant to a cat who has decided to choose an alternative elimination site.

It's also important to caution clients that if one cat in a household is experiencing litter box issues, then it is entirely possible that other cats will also do this. The larger the number of cats in a home, the more likely elimination disorders are. The longer these problems have been going on, the harder they are to stop.

The three causes of litter box issues in cats:

MEDICAL

If cats feel unhealthy or weakened by illness, their behavior will get affected, and this can impact litter box use. Real world scenarios that occur weekly in my practice involve cats who have inappropriate elimination associated with either diarrhea or constipation. These cats associate the discomfort they experience while defecating with the litter box and will very frequently find an alternative substrate. Cats with diarrhea may have urgency issues and literally may be unable to make it to the box. Cats with metabolic-altering problems like diabetes, kidney disease and hyperthyroidism can have litter box issues because they are producing more urine because of their increased thirstiness and that can result in both hygiene and urgency issues. Arthritic, older cats may be unable to gain access to the box or be so uncomfortable crouching to eliminate that they go elsewhere. Cats with urinary tract infections or with lower urinary tract disease are painful and that can drive them to urinate outside the box.

HYGIENE

Cats are an interesting combination of being extremely fastidious but at the same time not being repulsed by the smell of their own urine. But when litter boxes are stuffed to the brim, they might not be appealing to cats who want a clean surface to eliminate on.

The perfect box for a typical cat should be big—it should be about one and a half times the length of the cat, with a nice depth of about three inches of soft, unscented, scoopable litter. For an average cat, this is the pinnacle of boxes. The rule of thumb for multiple cat households is one box per cat and one extra for good measure. These boxes should be distributed within the house or apartment, not all lined up next to each other. And they should be scooped at least daily, and washed out every couple of weeks. The perfect box is uncovered and located in a low-traffic, quiet but accessible area.

Litter preference can vary based on the mom's preferences, but the most favored litter tends to be a scoopable, unscented litter with a beach sand texture. Those alternative litters like cedar shavings and crystals may not be acceptable to cats, and they frequently let us know that by finding another litter box alternative that is more to their liking. In the veterinary world, this may occur post-operatively when litters are changed to newspapers or pellets.

Cats should absolutely loooove their litter. This means they should get into the box, scratch at the litter, spend time with the box and get litter on their feet. If a cat enters the box but basically goes "yuck" and perches on the edge to urinate, or goes right in front of the box, or eliminates in the box but doesn't scratch around afterwards, or runs out and shakes his feet like he's touched something gross, there is a strong likelihood that something about that litter is not making him happy.

Cats should also be able to get to the box. Many households put litter boxes in basements, with stairs that are poorly lit or with doors that may or may not be closed. Many cats simply refuse to deal with these restrictions and will find another place to eliminate.

ANXIETY

These are the stressed-out cats who are using their urine as a marking tool. Urine is loaded with pheromones, and these cats are making statements about their level of stress and reinforcing their safe space via urine. Cats are not people. They actually like the smell of their urine and feel safe when surrounded by that familiar odor and pheromones. I tell my clients to think about that puddle of urine as their cat's go-to method of locking a door behind them.

The single biggest stressor for a typical house cat is the other cats in the household. One of the more intriguing things about cats is that their personalities can be so unique and different, but this also means that because of this we see confident cats and we see timid cats. And sometimes in a household, that personality mix might not gel.

More confident cats might literally "stake out" a litter box and prevent a more timid or nervous cat from using it. That shy cat doesn't automatically decide to hold it until there is access. Cats don't want to hold their urine, what they will do is simply find some other site that suits their fancy, and that site will likely become a preferred place to eliminate.

Cats who are being harassed at home by one of their housemates might be so intimidated that they feel the need to make themselves feel more secure by putting scent down via urine in strategic areas that feel to the cat like locking that door. These cats typically cannot escape the stressful situations at home, and the cumulative effects of this level of anxiety on a cat can be marked. There are also occasionally more confident or dominant cats who spray urine as a means of marking their turf, but the timid cats are the most common culprits for this disorder.

Urine by windows or doors might mean outside cats are the trigger. These cats might not be noticed by your clients, but the indoor cats are aware of them, and we will see both squatting to urinate and spraying, depending on whether we have timid cats trying to magically repel invaders with that urine "dead bolt" or confident cats saying no trespassing is allowed.

Cats also hate change, and anything that disrupts their routine can be a cause of anxiety or frustration. When your clients travel or go back to work, or get new significant others or kids, it can be very difficult for their cats to cope. The way these cats make themselves feel safer and more secure is all about smells and pheromones, and they frequently pick beds or laundry baskets to urinate on as a way to layer their scent with that of their owners. Combining those smells creates a mixture that has a powerfully soothing effect.

We sometimes don't appreciate how smell-oriented cats can be, which is why pheromone plug ins can help lower the temperature in a stressed-out household and relieve cat anxiety. Sometimes this step alone is enough to stop an elimination disorder.

ME--OUCH! HOW TO IDENTIFY AND HELP CATS WITH OSTEOARTHRITIS PAIN

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Cats get osteoarthritis, too, and they hurt just like dogs do. This disease is common and progressive, and some studies have shown that a staggering 90% of cats older than 12 years have some degree of joint dysfunction. The disease itself typically affects older individuals, and joint wear and tear is the prime cause.

Osteoarthritis (OA) is a disease of the joint's articular surfaces, characterized by joint pain, stiffness and a limitation of range of motion and mobility. As this disease advances, the articular cartilage deteriorates and new bone spurs can form at the affected sites.

Cats will frequently have significant pain associated with osteoarthritis but may have no radiographic joint changes evident, making diagnosis challenging and dependent on clinical findings and owner feedback. This is one reason that OA in cats has not been as readily identified and accepted as a true disease like it is with dogs and humans.

OA is a complicated and complex disease, and it can dramatically impact a cat's quality of life. Pain associated with OA can be debilitating, but it can be challenging to find a way to communicate this to clients who may feel that even if their cat is limping, that doesn't necessarily mean their cat is experiencing pain. Clients may feel that their caregiving ability is being questioned when they haven't taken action to help their "painful" cats, or that they haven't even noticed that their cats could be suffering from OA. This can result in resistance to the diagnosis and treatment of OA.

Pain occurs when a traumatic injury, such as a wound or sprain, causes an inflammatory response. The cells associated with inflammation, including macrophages and neutrophils, release prostaglandins and histamine, along with other mediators and cytokines of inflammation. This facilitates a complex process called nociception, which converts those cellular products of inflammation into an electrical impulse that can be transmitted up nerves. These signals get amplified or downplayed by the volume control effect coming from the dorsal horn of the spinal cord, which modulates what goes to the brain. The brain is the end receptor point for the electrical signal and it is where that pain signal gets converted into an actual sensation that we identify as pain.

Pain itself can be protective, such as when an acute injury happens and healing occurs by avoiding stressing the affected site. This is why an animal or human might limp to avoid putting pressure or strain on an injured joint. However, OA is different in that it is a progressive and pervasive disease, and that relentless build-up of pain signals coming from a diseased joint results in a wildly distorted pain response that effectively magnifies all sensations. It shifts that volume control lever in the dorsal horn to full throttle. There is absolutely no protective effect here, and the pain itself becomes the disease. The "wind up" or central stimulation that occurs with chronic pain becomes increasingly difficult to medically manage, and will unfortunately require multiple treatment modalities to attempt to control it.

Response to pain is uniquely personal and there are many different factors that impact how it is perceived. Sometimes, even your mood at the time an injury occurs will affect how that pain is felt. Whether or not it is socially acceptable to show pain, or if that pain should be hidden, such as with cats protecting their territory and doing all they can to avoid showing any weaknesses, and whether an individual tends to be more or less dramatic with how he or she experiences pain, all play a role in how pain is experienced. Pain ultimately is not perceived at all without the input of the brain, and there can be many different modulators to pain, primarily in the dorsal horn of the spinal cord, that will either escalate or diminish that pain sensation. This might be in the cat's best interest, such as minimizing the feeling of pain so the injured cat can escape a predator, but with OA, and any other chronic pain, the brakes come off and pain sensations become magnified and intense. This situation tends to worsen over time, which is why OA can be so progressively debilitating and resistant to therapeutic intervention.

The effects of joint pain in cats cause wide-ranging abnormalities. When normal mobility is impaired, this results in a loss of muscularity and subsequent lack of support for skeletal structures. Chronic pain also tends to sensitize the body, so pain can occur not only in proximity to the injury, but also in entirely unaffected areas of the body, leading to a situation where literally everything hurts. A cat who is painful from OA of the hips might growl or show discomfort from light stroking on the head, simply because of this reactivity. This syndrome, allodynia, is a devastating complication of chronic pain. Pain can also affect the cat's mental state, resulting in increased withdrawal, fear and anxiety, and sleep changes. These cats may no longer engage with their owners, but hide and resist any interactions. Many cats will also change their eating and litter box habits since accessing either area can be challenging. Cats may present in the veterinary office with litter box difficulties, and for older cats, pain is a frequent reason they may no longer use the box as consistently as they did when younger.

Clients often have difficulty identifying that their cat is uncomfortable, so open-ended exam room questions about mobility can be helpful in starting the conversation. Many cat owners think it is natural for cats to slow down with aging, and showing them video images of cats with mobility problems may be useful in allowing clients to see the difference between normal motion and abnormal motion. www.thenewscienceofoapain.com has short animated videos that can help clients identify painful cats.

Cats who are uncomfortable are reluctant to move around, and owners may identify changes in their behavior that are related to this condition. They will report that their cats are less active, jump and play less, avoid climbing stairs, do not engage with the family as readily, have elimination disorders, are matted and just seem grumpy. Many clients think this is normal with aging, and it is not unusual for these clients, who may not bring their cats in for consistent veterinary care, to believe that the cats are failing and need to be euthanized. Clearly, it will benefit these cats if OA can be identified and treated long before these types of problems surface.

Many cat owners are also very invested in being seen as their cat's caregiver, so our conversations with them about OA and pain should never be such that the client thinks we are accusing them of not being caring enough to identify pain. Pain is a loaded and emotional topic, and it is vital that we explain to our clients that cats are excellent at hiding signs of illness or infirmity, and that their behavioral changes associated with pain can be subtle and challenging to identify. We've all heard clients say that their cats are limping but aren't painful. We know that cats don't limp unless they have a very good reason for doing so, but because the cats are not vocalizing or otherwise communicating that they are in distress, owners may be unwilling to assign that behavior to a pain response. Counseling them that cats don't cry out when they are injured, or that limping always means that there is a painful body part, can be helpful and allow clients to understand how pain relief can be beneficial and even life-changing for their beloved cats.

It is imperative that we identify OA as early as possible, because of that escalation of disease seen with uncontrolled, chronic pain and how difficult it is to manage that pain. It is indeed possible to do

orthopedic exams on cats, and being slow and gentle and allowing the cat to acclimate to the exam room space can enhance the reliability of the findings. Joint swelling or crepitus or loss of normal muscularity can be useful in identifying problems, and letting the cat wander around the exam room can sometimes illustrate a lameness or a stilted gait. The most common joints affected by OA in cats are the hips, the shoulders, the elbows and the stifles. Many cats have bilateral disease, so they might not limp but simply walk in an abnormal manner. Client videos of their cats are also very useful in identifying impaired mobility.

Radiographic changes in cats are variable, and some very painful cats will not have osteophyte formation on x-rays. Conversely, some cats with radiographic changes will not be clinically affected, although there is certainly a reason with these individuals to begin early therapeutic intervention to avoid problems down the road.

OA treatment in cats is ideally multimodal, and there are both pharmacological and non-pharmacological treatments available. Most effective treatments involve the use of more than one medication or therapy. Treatment goals are focused on controlling pain, slowing disease progression and maintaining the cat's mobility. For success, analgesic therapy must be both effective and simple to administer. Nonsteroidal anti-inflammatory drugs (NSAIDs) have been the most commonly used direct treatment for OA in all species, but there are limitations in their use in cats, and there are no licensed long-term treatments available now for OA in cats in the United States. Non-drug treatments such as the use of omega 3 fatty acid food supplements or other nutraceuticals can be beneficial, but there are also no definitive studies showing long-term benefit. Environmental modification (ramps, chairs) can help affected cats gain access to desired places and modifying litter boxes to have low sides and creating easy access to feeding and sleeping areas can enhance a cat's quality of life.

The mainstay of direct pain treatment involves using NSAIDs such as prostaglandin inhibitors. These drugs work by blocking some of the components of nociception and minimizing the numbers of pain signals that reach the dorsal horn of the spinal cord. NSAIDs are the most effective treatment for OA in dogs, but cats are more sensitive to the effects the drug may have on renal function, and since OA disproportionally impacts an older population, many veterinarians are hesitant to use those drugs in cats who may already have some degree of renal insufficiency.

Adequan (polysulfated glycosaminoglycan) is another treatment modality, but its use is off-label for cats. Cold laser therapy can also be helpful, and some clients report a significant improvement in their cat's pain with this treatment. Gabapentin is another promising treatment, and can offer relief to cats with that chronic pain wind up effect by its ability to turn the volume down in the dorsal horn.

One of the most exciting new treatments is an anti-nerve growth factor monoclonal antibody that is specific for cats. This works in a similar fashion to NSAIDs in that it blocks production of compounds important in producing the nociception pain signal. The exciting news about this new product is it doesn't appear to adversely impact organ function and will be given via monthly injections in the veterinary office, effectively eliminating concern about side effects and also removing the negative impact on the human-animal bond that can frequently occur with the need for daily medications.

We must be careful not to underestimate the impact pain has on the human-animal bond. We know how important cats are to their families, and being able to identify and help those cats who are suffering from OA can support the bond people have with their cats, and give those cats longer and more fulfilling lives with their families. It is ultimately up to us, as veterinary professionals, to look for, recognize and manage these situations and to also understand the enormous impact pain has on cats and their families.

CATS DON'T MAKE YOU CRAZY! TOXOPLASMOSIS AND YOU

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Cats are frequently seen as mysterious and self-sufficient, which has worked against our best efforts to promote wellness care for them. Unfortunately, a persistent stereotype that cats are diabolical and malicious is widely accepted as the truth, and to this day, an alarming number of people still firmly believe that cats can suffocate babies.

Cats are popular pets, but certainly inspire strong negative feelings in people. And that tendency to think badly of cats only escalates whenever there are actual zoonotic diseases linked to cats that may impact human health. People are also much more knowledgeable about what a zoonotic disease is thanks to COVID-19, and can be willing to take steps to minimize exposure.

One unexpected benefit to the interest in zoonotic diseases is the publicity and discussion about transmissible cat diseases has opened the door to a deeper conversation with cat owners about proper care and what they can do to minimize risks through preventive health care measures. This is an opportunity for us to reinforce guidelines about parasite control and make sure that we consistently advocate for good, solid veterinary care for all cats. The Companion Animal Parasite Council has accessible resources that can help reassure and educate anxious clients: www.petsandparasites.org.

Media attention to cats lately has been resoundingly negative—we've been inundated with stories and features that label cats as bloodthirsty killers of wildlife, and there is a push to reclassify feral cats as an invasive species that is decimating songbird populations and spreading disease. We're also faced with concern over the threat of diseases in what seem to be ever-increasing numbers of unvaccinated, uncared-for cats, and of course, the shadow of zoonotic parasitic diseases and risks to people who might become exposed to those diseases through uncared-for owned or feral cats.

Toxoplasma gondii, a cat protozoan parasite, has long been feared for the very real risk it poses for pregnant women. Infection during pregnancy can cause significant fetal damage, up to and including death. This parasite is also under scrutiny for a possible link with human schizophrenia and increasing risk of suicide. There are also reports that toxoplasmosis may be implicated as a cause of marine animal diseases that include sea otter deaths and dolphin strandings.

The trajectory of cat-human relations has been very up and down throughout the centuries. Cats were first domesticated roughly 10,000 years ago, and probably hit their own personal high on the human interaction scale back in ancient Egypt, when they were worshiped as gods. Ancient Romans also revered cats as symbols of liberty.

Unfortunately for the cat, relations suffered a serious decline in status during the Middle Ages, when they became demonized throughout Europe. Cats were believed to be in alliance with witches and the devil, and they were enthusiastically hunted and killed in an attempt to ward off the evil that they embodied. Many historians believe that the subsequent decrease in the cat population allowed rats and mice (and their fleas) to flourish, which enhanced the transmission of the Black Death.

Public opinion didn't begin to slowly shift back in favor of the cat until well into the 1600s, but many Old Wives' Tales still singled out the cat as a source of danger and corruption. As recently as 2000, a sudden infant death syndrome crib death in the United States was falsely attributed to a cat being in the crib with the baby. But could there be a kernel of truth in some of those tales? The pervasive belief that cats could place curses on pregnant women might actually have its roots in the fetal disease caused by toxoplasma infection.

Can we veterinarians encourage cat ownership and protect the image of our favorite pet? How can we reassure people who are confused and frightened about the possible link between human mental illness and the cat? And how can we take steps to ensure that our planet's wildlife—both on land and in the water—is protected from feline predation and fecal-borne disease?

Of course, the simplest solution is to keep cats indoors. This protects cats from injury and illness, but it also minimizes the risk of fecal contamination in the environment, protects wildlife and decreases the likelihood that cats contract diseases that can be passed along to people.

Sinister, malevolent, mysterious, spooky—these are all adjectives used to describe the cat. These same adjectives, though, could describe a typical parasite. Parasites live inside other animals, and they use those hosts as food sources, as a safe haven from danger, and as a private guesthouse for reproduction.

Parasites complete their life cycle by skillfully avoiding their host's natural defense mechanisms. Toxoplasma is just one representative of that group of organisms that are engineered to succeed.

Many parasites, like Toxoplasma, have the ability to change their host's behavior by altering the host's brain. This manipulation can by through the release of proteins and hormones that alter behavior, or via changes the parasite can induce in host neurotransmitters. The host's brains are basically hijacked by the parasitic invaders in a modern-day Zombie takeover.

And a parasite such as Toxoplasma, that completes its life cycle only in the cat, but can infect people and alter human brain activity, is doubly concerning because of this zoonotic complication. *Toxoplasma gondii* is a single-celled protozoan parasite that reproduces in the gut of the cat, which shed the organism in their feces. Mammals and birds can then pick up the parasite through the ingestion of fecal-contaminated foods, and the parasite then moves into muscle and brain tissue, where it forms cysts. When cats eat infected mammals and birds, the cysts are liberated in the cat's intestines and toxoplasma completes its life cycle.

What toxoplasma can do to a host's brain is fascinating. It produces an enzyme that speeds up the production of the neurotransmitter dopamine. Dopamine is responsible for influencing motivation and rewards—it is the "pleasure" neurotransmitter and it is why we feel so blissful when we first fall in love. When dopamine production gets escalated in toxoplasma-infected mice, it decreases the mouse's fear response and changes the natural terror a mouse feels when it sees or smells a cat into something more trusting. In fact, when infected mice are in the presence of a cat, they get a jolt of dopamine, and literally become attracted to the cat and don't run away. This is a cat-specific reaction, and scientists believe that this is because the parasite needs to be in the cat to complete its life cycle.

Most people get infected with toxoplasmosis through exposure to oocyst-contaminated cat feces, although eating undercooked meat can be another source of exposure. Oysters and other shellfish can also be sources of infection, both for people and for marine life, and oocysts can survive for years in seawater. Healthy living rules don't always apply with toxoplasma and organic doesn't necessarily equate with healthier—the incidence of toxoplasma in organically-raised meats is significantly higher than that of factory-farmed meats. People who are infected will go on to develop toxoplasma cysts in their muscles and organs, and these cysts will persist for a lifetime. The disease can become "turned on" during any type of immunocompromise and those tissue cysts, or bradyzoites, will change into the rapidly-dividing tachyzoites that result in illness and disease.

When people are infected, does a similar neurotransmitter enhancement happen as it does in mice? There has been much speculation that a host of subtle personality traits, and actual mental illnesses, including schizophrenia, might result from just that sort of manipulation.

What researchers uncovered was concerning. There is evidence that infection with toxoplasmosis may be linked to the development of schizophrenia, suicide and a much greater likelihood to take risks that can result in motor vehicle accidents. There is also some evidence that human personality itself might be altered or somehow affected.

There are many questions about toxoplasmosis that remain unanswered. Is the suicide rate higher in people infected with toxoplasmosis? There is evidence that in countries where the infection level is highest—and in France it is approaching 85%--there is a higher rate of suicides. And even though there is a correlation between the incidence of toxoplasmosis in humans and the incidence of psychological problems, we know most people who are infected with toxoplasmosis do not have mental illnesses, so is there some underlying genetic susceptibility or individual variability that impacts whether a person goes on to become ill?

Most people will never become infected with toxoplasmosis. But people can and should benefit from the positive impact owning a cat can have on their own physical and psychological health. Keeping cats indoors will stop them from hunting and eating birds and mice, and we'll significantly decrease the possibility that they will become infected with toxoplasmosis or other zoonotic diseases. Keeping them indoors will also dramatically reduce the volume of cat feces in the environment, which will minimize infection risks to marine and other wildlife.

Healthy, owned, indoor cats pose no significant risks to people, so even immunocompromised people can own cats.

Our role as veterinarians must be as calm, steady proponents of best care practices. Our message has to be that the cat is valuable and should be treasured, and if this current "bad press" is driving people into the veterinary practices, perhaps we should even be grateful.

Greg Lewbart

COMMON TURTLE PROBLEMS

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A. *Introduction:*

Turtles are found throughout the world on all continents and in all oceans except Antarctica. There are 361 species of turtles (far fewer than snakes or lizards) as of October 2023. Turtles appeared in the fossil record over 200 million years ago and were on earth long before mammals and other forms of present day reptiles. They occur in terrestrial, freshwater aquatic, semiaquatic, and marine environments. They range in size from 11 cm to 185 cm and one species can weigh close to a ton, making it (the leatherback sea turtle) the world's largest turtle and one of the largest living reptiles!

B. *Anatomy and physiology:*

Witherington & Wyneken (2003) have published a nice color anatomy guide for the turtle (see Further Reading).

1. Turtles can live a long time and tortoises generally live longer than aquatic species. Reports of Aldabra and Galapagos tortoises living up to 260 years exist. Some species can be aged by growth rings on the scutes, but as the animal ages accuracy suffers. This does not hold true for many aquatic species that periodically shed their scutes.
2. Both the pelvic and pectoral girdles are contained entirely within the rib cage that is fused to the protective shell. The shell is a vascular bony structure that should be included when calculating drug dosages from the animal's weight.
3. Sexual dimorphism exists in many species. Male tortoises have a concave plastron and male aquatic turtles usually have very long toenails on their front feet. The tail is relatively larger in males than in females but this does not always hold true.
4. Turtles lack teeth but most possess a sharp beak called a rhamphotheca or tomium. They also have tongues that aid in prehending food but cannot be extended beyond the mouth (as is the case with many snakes and lizards).
5. The gastrointestinal tract is standard in that it includes a simple S-shaped stomach, liver, gall bladder, pancreas, spleen, small and large intestine. A cecum may be present but fermentation, when applicable, occurs primarily in the large intestine. Nearly all aquatic turtles must eat in the water.
6. Like most other reptiles, the heart has three chambers (one ventricle and two atria).
7. Turtles lack a diaphragm and since they are housed in a shell most have little or no abdominal breathing component. Most pressure changes allowing for lung expansion are accomplished by muscles in the pockets surrounding the fore and hind limbs. Aquatic species can also respire through their skin and the mucus membranes of the throat and cloaca.
8. Turtles have paired kidneys and a cloacal opening for the urogenital and gastrointestinal tracts. The ureters open into the cloaca and urine then passes from the cloaca to the more cranial urinary bladder.
9. The chelonian cloaca is divided into three zones: the cranial coprodaeum where the rectum attaches; the medial urodaeum where the ureters and reproductive tracts attach; the proctodaeum where urinary and fecal waste are stored.
10. All turtles have internal fertilization. Courtship is usually a part of most chelonian copulation. Some freshwater species (sliders, cooters) have an elaborate ritual in which the male waves its long forelimb nails in front of the female's face. The single phallus is employed during copulation. Unlike snakes and lizards, the chelonian penis has erectile tissue. The semen is conducted through a seminal groove that

terminates between distinct folds (known as plicae) of the glans. Some female turtles have a clitoris located in the ventral cloaca that anatomically resembles the penis.

11. All turtles lay eggs and most bury them in the earth. Some species may lay several clutches per year and females of certain species can store sperm for several years.
12. Sea turtles possess special salt glands in their head behind each eye that allow them to drink seawater.

C. Anesthesia/analgesia/restraint:

1. Simple procedures like radiography and blood sampling usually do not require sedation. Most turtles will remain still for the time it takes to produce a radiograph.
2. Many textbooks and review articles adequately summarise the literature (e.g., McArthur et al., 2004; Mader 2006; Jacobson, 2007; Mitchell and Tully 2008; Sladky and Mans, 2012; Gibbons et al., 2013; Mader & Divers, 2014, Divers & Stahl, 2019). A number of agents are used in turtles including injectable and inhalant compounds. We have had favorable results with many chelonian species using 3 to 10 mg/kg propofol IV for induction or relatively quick procedures like fish hook removal. Alfaxalone at 5-10 mg/kg either IM or IV is quite efficacious for most species. Ketamine hydrochloride at a dose of 5 to 10 mg/kg combined with medetomidine or dexmedetomidine at 50 mcg/kg IM or IV works very well. A study on mature female nesting leatherback sea turtles (*Dermochelys coriacea*) by Harms et al. (2007) found the medetomidine/ketamine combination with atipamezole reversal satisfactory for field anaesthesia. This regimen may also be used in order to sedate a turtle for intubation and placement on inhalant isoflurane or sevoflurane. Telazol® is used by some clinicians to anaesthetise chelonians. Barbiturates should be avoided if possible because of deleterious effects. Butorphanol, ketoprofen, buprenorphine, morphine, and other agents have been used for analgesia in chelonians. A study (Sladky et al., 2007) found that morphine may be superior to butorphanol in turtles. Buprenorphine can also be used and has been studied in redeared sliders (*Trachemys scripta*) by Kummrow et al. (2008).

D. Blood collection and hematology:

1. There are several sites for blood collection in turtles. These include the dorsal caudal vein, jugular vein, supra-occipital (dorsal cervical) sinus, sub-carapacial sinus, and brachial vein. The tail tends to be short compared to other reptiles and the shell frequently is in the way so accessing the tail can be challenging in some cases. The jugular vein can be difficult to access, especially if the turtle's head cannot be extracted. A small gauge needle place at a 45-degree angle near the lateral carpus (brachial vein) is a good place to bleed many species of turtle including tortoises.
2. Please refer to Diethelm (2005), Campbell (2006), and Campbell & Ellis (2007) for detailed clinical pathology reference ranges and other information. Divers and Stahl (2019) is an excellent resource as well.

E. Non-infectious diseases:

1. **Abnormal beak/tomium.** Some turtles and especially tortoises in captivity will develop overgrown "beaks." This is usually due to the consumption of unnatural foods. Can be corrected by trimming or grinding down with a Dremel drill that is frequently used in birds with similar problems.
2. **Cracked Shell.** This is unfortunately a very common problem in turtles and tortoises. Chelonians have two things working against them. They like to cross roads, and they are slow! Lawn mowers, weed wackers, and other machinery also take their toll. The wound should be flushed very well with a dilute antiseptic like Nolvasan® (1:40) with clean water, or if the coelomic cavity is exposed, a physiological saline. The older literature describes techniques to repair shells using epoxy, fiberglass, and hoof or

dental acrylic. While these techniques do have value, they should be limited to fractures of peripheral shell areas not involving an exposed coelomic cavity. Here at the NC State-CVM, we utilize open surgical techniques that will be taught to you in the turtle shell repair laboratory. Properly placed metal clothing hooks and surgical wire work very well to reduce and stabilize shell fractures. The human artificial skin product, Tegaderm®, may be used to
temporarily close large defects in the shell. External "heat-pliable" orthopedic materials

(Orthoplast®, Hexalite®) are also effective in reducing and stabilizing shell fractures. An adhesive bandage called Mefix® is used on occasion by the Turtle Rescue Team for temporary shell stabilization. In a pinch duck tape can be used!

- Injured turtles should also receive fluids, analgesics, and aggressive antibiotic therapy. Post-operative nursing is extremely important in the survival of "cracked" turtles. Assist feeding, appropriate temperature, rest, and access to fresh water are a must.
- While the shell is protective, it also makes diagnosis of internal injuries very difficult. Simply repairing the shell and restoring it to its original appearance does not produce a "cured" turtle or tortoise. I have seen turtles live for weeks with severe internal injuries before succumbing to peritonitis. We generally do not feel a shell trauma turtle is releasable until it is eating on its own and has been allowed to recuperate for at least 3 months.

3. **Hypovitaminosis A.** Usually a disease of freshwater aquatic turtles. Turtles frequently present with swollen eyes, a nasal discharge, tympanic (aural) abscesses, and in advanced cases, respiratory distress. The condition is especially common in captive box turtles and small freshwater aquatic turtles that may be receiving an inadequate diet. The lack of vitamin A results in metaplasia of squamous cells that causes a decrease in mucus production and an increase in the production of keratin. Animals should initially receive a parenteral dose of vitamin A (see formulary) and then should be placed on a well balanced diet that contains appropriate levels of vitamin A. Dog and cat foods as well as some of the commercially available reptile "sticks" and pellets provide adequate levels of vitamin A. Care should be taken not to over supplement with vitamin A (see below). There is some evidence that environmental organochlorine toxicity inhibits vitamin A metabolism in wild box turtles and contributes to aural abscesses and upper respiratory disease.
4. **Hypervitaminosis A.** This problem occurs secondary to administration of supplemental vitamin A. Clinical signs include sloughing of the skin and secondary bacterial infections of the exposed tissues. To prevent this condition, turtles should receive just a single dose of injectable A followed by a change in the diet or perhaps oral vitamin A supplementation in the form of cod liver oil that can be dabbed onto the food or tomium.
5. **Metabolic bone disorder.** Certainly not the problem it is in iguanas but it does occur in turtles and tortoises. Turtles fed primarily organ meats (liver, heart) or pure muscle (beef, pork, chicken) will develop metabolic bone disease and other nutritional problems. If these foods must be fed they need to be supplemented with calcium and multivitamins. Crickets and mealworms are two insect foods that have a poor calcium to phosphorus ratio (more phosphorus than calcium). Some people "shake and bake" these insects with powdered vitamin and calcium supplements before feeding and others simply feed the insects powdered milk to increase their nutritional value.
6. **Egg retention (dystocia)**. Dystocia appears to be a fairly common problem among captive turtles. A number of factors have been linked to this condition including lack of appropriate nesting substrate, dehydration, hypocalcemia, poor nutrition, and trauma. Radiography is very helpful in diagnosing this problem, however, eggs can frequently be palpated digitally within the coelomic cavity. Affected animals should be given a physical examination along with a thorough history. Once the animal is properly hydrated and nourished, a suitable nesting substrate can be provided. If this conservative approach is unsuccessful, then a regimen of oxytocin (see formulary) preceded by calcium gluconate and fluids may be in order. Before using oxytocin the clinician needs to be sure there is not an obstruction. It can be

difficult to determine if a turtle with eggs is truly "eggbound." History, time of year, and egg morphology can help make this determination. Eggs can even end up in the urinary bladder, most likely from being "retropulsed" from the cloaca. Surgery and endoscopy have been used to remove such eggs.

7. **Ruptured oviduct.** While apparently not a common problem, turtles with obstructive dystocia are especially at risk, especially if given oxytocin or arginine vasotocin. This can be a fatal condition due to peritonitis and endotoxemia.
8. **Prolapsed phallus.** Owners quickly recognize this condition. If treated early it may be possible to reduce the phallus (a lidocaine gel may help with this procedure) and then loosely purse-string the vent closed (leaving enough of an opening for urates and feces to pass). If the phallus has been out for a period of time it will appear inflamed or even necrotic. In these situations amputation is the best option. While the turtle will no longer be reproductively sound, he will lead a relatively normal life since urine flows directly from the cloaca to the vent.
9. **Gout.** Gout has been reported in several species of turtles. Accumulation of uric acid crystals or tophi is most commonly secondary to water deprivation or a protein imbalance in the diet (see snake notes). Treatment with NSAID's and allopurinol may be warranted.
10. **Shell Rot.** Primarily a disease of aquatic species. Usually secondary to the turtle spending all of its time in the water or water that is of poor quality. Treated by correcting water quality problems and providing a place for the turtle to "haul out."

E. *Infectious diseases:*

1. **Viral Diseases.** A number of viral diseases have been reported in sea turtles. Important viral diseases of freshwater and terrestrial chelonians include Herpesvirus Disease of tortoises (multiple clinical signs and high mortality may occur) and Iridoviral (*Ranavirus*) Disease of Box Turtles (mortality may be high and clinical signs include pharyngeal ulcers, focal skin sloughing, and marked lethargy).
2. **Bacterial problems.** Like snakes and lizards, turtles are prone to a number of bacterial pathogens, most of them being gram negative. In addition to infection of traumatic wounds, debilitated chelonians are vulnerable to respiratory diseases caused by bacteria. Aquatic turtles with lung disease will frequently float in the water asymmetrically or have difficulty surfacing or submerging. Radiographs can help confirm the presence of a pneumonia (the lung fields are quite large and located in the dorsal portion of the coelomic cavity beneath the carapace). A lateral or anterior-posterior view is the best way to visualize the lungs of turtles. Culture and sensitivity tests will help in the diagnosis and treatment of bacterial diseases.
    - Septic cutaneous ulcerative disease (SCUD) is a problem most frequently observed in freshwater aquatic turtles like sliders and cooters. The causative agent is *Citrobacter fruendii*, a Gram-negative rod. Affected animals may present with deep skin ulcers in a variety of locations.
    - Mycoplasmosis, also termed Upper Respiratory Tract Disease (URTD), is a well-studied and serious disease affecting some chelonian species, especially tortoises. Affected animals generally experience a chronic infection with varying degrees of clinical signs. Mortality may occur but is rarely acute. Infected animals probably only rarely clear the organism. Treatment regimens are anecdotal but worth pursuing in some cases. Diagnosis can be accomplished by culture, plasma ELISA, or PCR testing.
    - *Salmonella* spp. has serious zoonotic potential and proper hygiene should be emphasized to owners with pet turtles, especially in households with young children. Numerous studies have reported on this important topic. The problem seems to be much more common in captive turtles. While Salmonella can cause severe disease in humans, turtles are able to harbor and shed the organisms without showing clinical signs.

3. **Fungal diseases.** Turtles are prone to both superficial and deep mycoses. There are several reports in the literature of fungal granulomas in the lungs of turtles and fungi cultured from skin and shell tissues are even more common. Systemic infections are very difficult to treat and are usually secondary to a poorly functioning immune system. Superficial fungal infections can be readily treated with topical antifungal agents and proper hygiene. Decreasing the pH of the water below 6.5 may also help alleviate fungal problems. Fungi that have been cultured from superficial lesions of turtles include *Basidobolus ranarum*, *Dermatophyton* sp., *Fusarium* sp., *and Aspergillus* sp. An emerging (at least in terms of diagnosis) fungal disease of aquatic turtles (including box turtles) is called *Emydomyces testavorans* (Woodburn et al., 2019). This pathogen, which appears to only affect the shell of turtles, is being diagnosed in new species and in new geographic areas on a regular basis. This pathogen is related to other important reptile fungal pathogens like *Ophidiomyces* and *Nannizziopsis*.
4. **Protozoal diseases.** Fortunately for turtles, they are rarely infected with *Entamoeba invadens* or *Cryptosporidium sp.* Turtles can be sub-clinical carriers of amoebiasis. There are reports of protozoans causing disease in chelonians, but by the same token, the appearance of protozoans in a stool sample does not mean there is a problem. The *Hexamita* / *Spironucleu*s flagellates do cause disease in turtles, and if present in large numbers, may be treated with metronidazole. A wide variety of protozoans have been reported in turtle blood. Since these parasites are not usually a clinical problem they will not be elaborated upon but the student should be aware that they exist.
5. **Helminth parasites.** Turtles have their share of nematode, cestode, trematode and acanthocephalan parasites. Diagnosis is made by fecal examination and history (turtles captured in the wild will tend to have broader and heavier parasitic loads than captive raised animals). See the notes on snakes and lizards and consult the reptile formulary for drugs and doses.
6. **Leeches.** These parasites are strictly external and are found on many wild freshwater and marine turtles. In severe cases they may cause anemia and they can act as vectors for blood borne parasites. Treatment is by plucking them off of the turtle.

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V. Publications Containing Current Information of Diseases and Husbandry of Reptiles

- American Journal of Veterinary Research (periodically)
- Copeia
- JAVMA (periodically)
- Herp Review
- Journal of Exotic Pet Medicine
- Journal of Herpetological Medicine and Surgery

- Journal of Herpetology
- Journal of Wildlife Diseases
- Journal of Zoo And Wildlife Medicine
- Reptiles Magazine
- The Veterinary Clinics of North America; Exotic Animal Practice, W.B. Saunders (Elsevier)
- Zoo Biology

VI. Specialty Boards

- In June, 2009 the American Board of Veterinary Practitioner's (ABVP) certification in Reptile and Amphibian Medicine was approved by the AVMA and the first credentialing and examination was offered in 2010.
- Both the American and European Colleges of Zoological Medicine offer board certification and reptiles are included in these specialty certifications.

INTRODUCTION TO AMPHIBIAN MEDICINE

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Modified and updated from NC State-CVM VMC-931 Course Notes (M.K. Stoskopf) and International Conference on Diseases of Zoo and Wild Animals 2013 Proceedings.

A. Introduction

Amphibians are a fascinating and extremely important taxonomic group of animals. They are valued as environmental sentinels, biomedical research subjects, public display animals, private pets, and even as a human food source. Wright and Whitaker (2001) provide a detailed resource on general amphibian husbandry and

medicine. A 2012 husbandry guide produced by the Association of Zoos and Aquariums (Poole, 2012) provides a thorough review of amphibian natural history and husbandry. The current (2019) *Mader's Reptile and Amphibian Medicine and Surgery* is a valuable resource.

The class **Amphibia** is broken into three orders, 75 families, containing 8,731 species http://research.amnh.org/vz/herpetology/amphibia/ accessed February 20, 2024)*.

1. **Anatomy and Physiology**

Most species with a two-stage life cycle.

Many can respire through their skin.

Most species have lungs (plethodontid salamanders do not).

All possess a three-chambered heart.

Virtually all are carnivorous as adults.

The taxon has very large RBC's.

Most have external fertilization and lay eggs in wet or moist areas (there are exceptions).

2. **Taxonomy and Natural History**

There are three orders in the Class Amphibia.

I. CAUDATA - Salamanders and sirens.
II. ANURA - Frogs and toads.
III. GYMNOPHIONA -The caecilians. These are elongate, limbless burrowing amphibians with small eyes and a short-pointed tail when present.

B. Anesthesia and Analgesia

With the frequent, and increasing veterinary engagement with amphibians, it is necessary to provide both analgesia and anaesthesia for these animals, especially when surgery is involved.

Analgesia with regards to post-operative pain management in amphibians is a pertinent topic. The literature is well represented with studies on opioid agonists; most of these studies date to the 1980's and 1990's (Pezalla and Stevens, 1984; Stevens et al., 1994; Stevens, 1996; TerrilRobb et al., 1996; Newman et al., 2000) but several have been published in the last 15 years (Stevens, 2004; Mohan and Stevens, 2006; Koeller, 2009; Stevens, 2011). A number of nonsteroidal anti-inflammatory drugs (NSAID) have been investigated in amphibians including, but not limited to, flunixin megalamine, indomethacin, and ketorolac (Stevens, 1996; Terril-Robb et al., 1996). All of these agents appeared to produce analgesic effects in the species tested. Meloxicam (0.1 mg/kg IM) suppresses prostaglandin E2 (PGE2) (the most predominant prostaglandin) post injury in American bullfrogs, *Rana catesbeiana* (Minter et al., 2011). This indicates that administering an NSAID like meloxicam in anurans, and perhaps other amphibians, can elicit an anti-inflammatory response and possibly have an analgesic effect.

Anaesthetic agents

A number of compounds have been used to anaesthetise amphibians including alfaxalone, benzocaine (Orajel®), eugenol, isoflurane, propofol, and sevoflurane. A 2009 article reviews the topic (Mitchell, 2009) and drugs and dosages appear in the new Carpenter Formulary (Whitaker & McDermott, 2017). A 2018 article compared a number of agents on *Xenopus laevis* (Smith et al., 2018). Historically the most commonly employed anaesthetics have been isoflurane and MS-222. Recent studies have illuminated a number of agents including benzocaine, eugenol, propofol, and sevoflurane.

MS-222

This sodium channel blocker is widely used for amphibian anaesthesia and has a good margin of efficacy and safety when applied appropriately at a wide range of dosages. A neutral-buffered stock solution can be made by dissolving 1 gram of MS-222 and 1 to 2 grams of sodium bicarbonate (0.5 grams should work but 1:1 makes the math simple) in 100 millilitres (mls) of distilled water. This solution will contain 10 mg/ml of MS-222 and should be labelled appropriately. The stock solution should be protected from light and adequately labelled with the concentration, date of preparation, and name of person who mixed the solution. The stock solution should be effective for at least 30 days and in most cases longer. For most amphibians the immersion dose is 1-5 grams/L.

Isoflurane

This halogenated ether compound has been used to anaesthetise amphibians via immersion, inhalant, and topical routes (Mitchell, 2009). Numerous references discuss the details of its use. Frequently it is simply used to effect as a liquid soaked into cotton balls and then placed in close proximity to the amphibian (Major et al., 2011; Pojman et al., 2011).

Eugenol

In African clawed frogs 350 mg/L was successful as an immersion anaesthetic (Guenette et al., 2007; Goulet et al., 2010). The latter paper determined that smaller frogs (approx. 10 grams) were anaesthetised for a shorter time than medium sized frogs (approx. 30 grams). A subsequent toxicity evaluation paper (using the aforementioned dose) found that even after a single administration eugenol immersion causes renal tubular apoptosis, and, after three successive daily dosings, hepatic necrosis can result (Goulet et al., 2011).

Benzocaine

Orajel® is an over-the-counter commercial preparation used for local analgesia in people; it contains 20 % benzocaine. In a recent study comparing MS-222 and Orajel® in four North American amphibian species, the authors found that 20 % benzocaine provided adequate anaesthesia for amphibians, and acted faster and for a longer period compared to MS-222 (Cecala et al., 2007). It was determined to be slightly more economical than MS-222.

Propofol

A study on the tiger salamander (*Ambystoma tigrinum*) comparing propofol and clove oil found that propofol was an effective general anaesthetic for a surgical plane when given at 35 mg/kg intracoelomically in 5/6 salamanders (Mitchell et al., 2009). An earlier study, examining propofol use in the White's tree from (*Pelodryas caerulea*) determined that a safe and effective dose in this species was 30 mg/kg intracoelomically (von Esse and Wright, 1999). Propofol was not recommended as an immersion anaesthetic for African clawed frogs (*Xenopus laevis*) in a study by Guenette et al. (2008). At 88 mg/L for 15 minutes it produced only light anaesthesia and at 175 mg/L all tested frogs died. Thirty-three 115-165 gram female frogs were included in the study.

Sevoflurane

While there do not appear to be any in vivo studies examining sevoflurane in amphibians, one study investigated its use in vitro on bullfrog (*Rana catesbeiana*) skin and several different silastic membranes (Ardente et al., 2008). The authors determined that sevoflurane absorption was positively affected by pluronic/lecithin organogel (PLO).

C. *Surgical Techniques*

Introduction

Surgery can be a productive option for amphibians when such invasive therapy is warranted. Gentz (2007) reviews surgical approaches and techniques in a review article that also addresses general anatomy, physiology, and anaesthesia considerations. Since amphibians are such important and widely utilised research animals, many techniques, such as ovariectomy and application of tracking/telemetry devices, are reviewed in this article.

The animal's skin (aside from the area close to the incision) should be kept moist throughout the surgical procedure. During prolonged procedures, a red rubber catheter and large syringe can be used to carefully moisten the amphibian patient without splashing water into the incision site. Patient monitoring can be performed with a pulse Doppler.

A clear plastic avian-style drape has many advantages for amphibian surgery. The plastic helps retain moisture around the patient, does not allow moisture to leak through and compromise the surgical field, and provides a working surface which stray suture can contact without contamination. A rim of petroleum jelly can be used to adhere the drape to the amphibian if desired.

Surgical preparation should minimise disruption of the skin and mucus, as these are major barriers to infection. A simple swipe along the intended incision site with a cotton swab soaked in sterile saline can suffice. Using povidone iodine or similar compounds is discouraged since these can be toxic to amphibians.

Bipolar cautery works well for haemostasis during amphibian surgery. Needles with a cutting tip facilitate skin penetration. With regards to suture selection, Tuttle et al. (2006) found that monofilament nylon was the most appropriate of five suture types examined in the skin of the African clawed frog. Levesque et al. (2009), describes wound healing in the axolotl (*Ambystoma mexicanum*).

A variety of case reports appear in the literature regarding surgical approaches to a clinical challenge. These include removal of a mandibular melanosarcoma in an axolotl (*Ambystoma mexicanum*) utilising a skin graft from the patient (Menger et al., 2009), femoral fracture repair in an American bullfrog (Royal et al., 2007), and a laminectomy in a two-towed amphiuma (Waffa et al., 2012).

Blood Collection

Peripheral venipuncture, the mid-ventral abdominal vein, and cardiocentesis have all been used.

Drug Administration

Intramuscular (IM) injections are usually made in the posterior muscles of the forelimb or hind limb in salamanders and the hind limb of frogs. Most medications are readily absorbed rapidly when applied to the skin of amphibians and this is a common route for medications that otherwise are injected intracoelomic (ICe) or subcutaneously (SQ). ICe injections are made in the right side of the abdomen in the posterior quadrant.

Important Diseases

Lucke's Tumor. Lucke's Tumor is a renal adenocarcinoma affecting the northern leopard frog (*Rana pipiens*) caused by a herpesvirus. This was the first neoplasm demonstrated to be caused by a herpesvirus. Lucke published his belief that a filterable virus was associated with the tumor in 1934. Koch's postulates were fulfilled in the 1970's. There is a seasonal change in tumor prevalence with tumors being most common in early spring as frogs emerge from hibernation. Virus is shed in frog urine. Oocytes and young embryos are susceptible to infection with virus.

Ranavirus. This highly contagious and serious disease of amphibians can cause high morbidity and mortality among infected animals. These viruses belong to the Iridoviridae and are likely transmissible to reptiles and perhaps other taxa. Sound quarantine and biosecurity measure should be followed in order to prevent and/or minimize the impact of these organisms. Details on this disease can be found in the Reference Section of these notes.

Red Leg Syndrome (RLS). The term *red leg* is used to describe a set of clinical signs that include erythema and ecchymoses on the underside of the legs and abdomen of frogs and salamanders. Affected amphibians may also show skin ulceration, anemia and ascites. These signs are typical of a number of bacterial septicemias and are not specific for infections with *Aeromonas hydrophila* but this bacteria is commonly cultured from and incriminated in the pathogenesis of this syndrome. *Aeromonas hydrophila* is considered an opportunistic pathogen of amphibians. It is essentially ubiquitous in aquatic environments. It establishes itself in stressed or immunosuppressed animals. Latent infections are common. Control of the disease centers on proper sanitation and environmental quality. Particular care should be taken to avoid the build up of high levels of organic matter in tanks. In the face of an outbreak, antibiotics should be administered based upon culture and sensitivity results. Numerous other pathogens, including viral and fungal organisms, can result in clinical signs consistent with RLS.

Mycobacteriosis. Amphibians are susceptible to infections by several atypical Runyon IV mycobacteria including *Mycobacterium fortuitum*, *M. marinum*, *M. xenopi*, and *M. thamnopheos*. These organisms are ubiquitous saprophytes, found commonly in nature. Normally amphibians have a high degree of natural resistance to disease. Infection with mycobacteria appears to require immunosuppression of the amphibian host.

Chlamydiosis. *Chlamydia psittaci* has been diagnosed in *Xenopus* and other anurans. Clinical signs mimic an acute bacterial septicemia. No successful therapy regimen has been documented.

Chromomycosis. Amphibians frequently contract fungal infections. Chromomycosis is caused by pigmented fungi that may result in characteristic pigmented granulomas being disseminated throughout the internal organs. Skin lesions can also be observed. Therapeutic efforts have been unrewarding to date. This is a zoonotic disease.

Chytridomycosis. This serious fungal disease of amphibians, caused by *Batrachochytrium dendrobatidis*, is believed responsible for an unprecedented global amphibian population decline. The wide introduction and dissemination of this pathogen is most likely the result of human activity. In the past decade much effort and emphasis has been placed on the prevention, control, diagnosis, and treatment of this problem. Diagnosis is based on biopsy/necropsy followed by histopathology and PCR testing. Individuals and captive populations have been successfully treated with antimicrobial agents, such as florfenicol and itraconazole, combined with supportive care and environmental disinfection. For a thorough review of chytridomycosis see Van Rooij et al., 2015 and Fisher and Garner, 2020).

Saprolegniasis. Fungi (water molds) of the genus *Saprolegnia* can cause dermatitis that can be severe. This is usually a secondary pathogen and readily controlled with proper animal handling, husbandry, and hygiene.

Lung Worm. *Rhabidias* lungworms can cause pneumonia in captive amphibians. Amphibians may be a source of infection for reptiles where the parasite is considered a serious pathogen.

Cutaneous Capillariasis. *Xenopus* are susceptible to a capillarid infection of the skin that causes irritation, blotchy skin, skin sloughing, and may predispose toward bacterial superinfections that can cause death.

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VI. Publications Containing Current Information of Diseases and Husbandry of Amphibians and Reptiles

- American Journal of Veterinary Research
- Copeia
- Exotic DVM Magazine (published until 2011)
- JAVMA (periodically)
- Journal of Exotic Pet Medicine
- Journal of Herpetological Medicine and Surgery
- Journal of Herpetology
- Journal of Wildlife Diseases
- Journal of Zoo And Wildlife Medicine
- Reptiles Magazine
- The Veterinary Clinics of North America; Exotic Animal Practice, W.B. Saunders (Elsevier)

- Zoo Biology

VIII. Specialty Boards

- In June, 2009 the American Board of Veterinary Practitioner's (ABVP) certification in Reptile and Amphibian Medicine was approved by the AVMA and the first credentialing and examination was offered in 2010. See link below for details:

  http://www.abvp.com/categories_reptileamphibian.htm

NO SPINE NO PROBLEM: INTRODUCTION TO INVERTEBRATE MEDICINE

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Portions of these notes are adapted from: Lewbart GA (ed). 2006. Invertebrate Medicine, Blackwell Publishing, Ames, IA, 327 pp. Lewbart GA (ed). 2012. Invertebrate Medicine, 2nd Ed., Wiley-Blackwell Publishing, Ames, IA, 488 pp., and Lewbart GA (ed). 2022. Invertebrate Medicine, 3rd Ed., Wiley-Blackwell Publishing, Ames, IA, 725 pp. Where indicated, these notes contain excerpts from the following book chapters (specific references not included):

I. Introduction:

Before we get to the topic of invertebrate medicine we should first answer the question, "what are invertebrates?" Invertebrates are a diverse group of animals that lack a vertebral column or backbone. They make up the majority of the animal kingdom and encompass a wide array of species (over 95% of those described) with varying adaptations and characteristics. Invertebrates are found in nearly all of the world's habitats, including aquatic, marine, and terrestrial environments.

Some fundamental characteristics of invertebrates:

1. Absence of a backbone: The most defining characteristic of invertebrates is the absence of a vertebral column (backbone or spine). This distinguishes them from vertebrates, which are animals with a well-developed internal skeleton composed of cartilaginous or bony vertebrae.
2. Diverse body structures: Invertebrates exhibit an incredible diversity of body forms and structures. They include animals with soft bodies, hard exoskeletons, and a variety of appendages for feeding, locomotion, reproduction, defense, and other functions.
3. Exoskeletons: Many invertebrate groups have exoskeletons, which are external hard coverings usually made of chitin. These exoskeletons provide protection, support, and a firm surface for muscle attachment. In some cases, these exoskeletons must be shed (a process called molting) to accommodate growth and heal injuries or defects.
4. Nervous System: Invertebrates have a wide range of nervous system complexities, from simple nerve nets (jellyfish) to more complex systems with well-defined brains and sensory organs (some mollusks, arachnids, crustaceans, and insects).
5. Reproduction: Invertebrates employ various reproductive strategies, including sexual reproduction (with internal or external fertilization) and asexual reproduction (such as budding or fragmentation).
6. Segmentation: Some invertebrates exhibit segmentation, where their bodies are divided into repeating segments. Each segment may have specialized structures, such as gills, legs, or sensory organs. Examples include the annelids, crustaceans, and insects.
7. Habitats: Invertebrates inhabit virtually every ecosystem on earth, from the highest mountainous regions to deep-sea hydrothermal vents and virtually everything in between. They play crucial roles as decomposers, pollinators, predators, and as prey.

8. Taxonomic Diversity: Invertebrates encompass a wide variety of taxonomic groups, including coelenterates (jellyfish, anemones, corals), mollusks (snails, clams, octopuses), annelids (oligochaetes, polychaetes, leeches), arthropods (insects, spiders, crustaceans, arachnids), echinoderms (sea stars, sea urchins, sea cucumbers), and many more.

Due to their incredible diversity and ecological importance, invertebrates are the focus of extensive scientific research and conservation efforts. Invertebrates contribute to ecosystem functioning and provide valuable insights into evolutionary processes and adaptation.

There are currently over 40 recognized phyla of invertebrates (not including the protozoans). Many of these phyla are little known to veterinary medicine, but for no better reason than they contain few species, have microscopic representatives, or possess no *obvious* economic value. Each phylum and its members are important to the diversity and survival of the planet, even if the group is only studied by a relatively small number of scientists. Writing a comprehensive article for the welfare of all invertebrate groups would be an inefficient task. Thus, we have elected to include information on the metazoan taxa frequently encountered by veterinarians and researchers.

It should be noted that **invertebrates are not considered animals by the North Carolina Veterinary Medical Board (NCVMB) and likely other USA and international regulating veterinary boards**: *(2) Animal. - Any animal, mammal other than man and includes birds, fish, and reptiles, wild or domestic, living or dead.*

II. Porifera (Sponges)

The phylum Porifera is a diverse group of primitive animals commonly referred to as the sponges. Until the early 1800's sponges were actually classified as plants. Sponges occur in the fossil record back to the Precambrian (over 600 million years ago) and were the most important contributors to reefs during the Palaeozoic and Mesozoic Eras (Hooper and Van Soest, 2002). All members lack defined organs; differentiated cells within connective tissue perform necessary biological functions. A unique system of water canals facilitate transport of food, waste products, and gametes. Nearly all are sessile and most species are marine. Most of the 15,000 species are marine but about 3% of sponges live in freshwater environments. Sponges are normally found on firm substrates in shallow water, although some occur on soft bottoms.

Key Points:

1. Sponges maintain a close association with a variety of bacterial genera, some of which can be pathogenic.
2. Virtually nothing is known about analgesia, anesthesia, and therapeutics of sponges.
3. Sponges seem to tolerate surgical manipulation in the form of cutting and autografting.
4. Sponges are an integral part of coral reef and other aquatic communities.
5. Natural products produced by sponges are important to biomedical science.

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III. Coelenterates

This large phylum includes the comb jellies (Ctenophores), Hydrozoans (hydras, fire coral, Portuguese Man-O-War), Scyphozoans (jellyfishes), and Anthozoans (stony corals, soft corals, sea anemones). This is an economically important group for research, environmental monitoring, public and private display, and tourism. Coral reefs collectively are one of the most beautiful, diverse, and fragile ecosystems on the planet. Jellyfish exhibits are now some of the most popular displays in public aquariums and upscale restaurants throughout the world.

Key Points:

1. Some diseases of hard and soft corals have been well documented. The nomenclature for many of the infectious diseases is in the process of standardization.
2. Many coelenterates are important indicators of ecosystem health.
3. Trauma and "inversion syndrome" are major concerns when keeping captive jellyfish.
4. A variety of therapeutic compounds have been used in this phylum, almost exclusively on an empirical basis.
5. Our overall knowledge of coelenterate medicine and surgery is minimal but growing steadily. *Fragging* is a term used to describe "surgical propagation" of hard and soft corals utilizing a variety of instruments, adhesives, and substrates.

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IV. Gastropod Mollusks (Adapted from R. Smolowitz. 2006.

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The gastropods belong in the phylum Mollusca and include over 80,000 marine, fresh water and terrestrial species. All gastropods have a ventrally flattened foot that provides locomotion along the various surfaces of their habitats. The group includes snails, slugs, sea hares, nudibranchs, slipper shells, conchs, whelks, and abalone, among many others. The use of gastropods as laboratory animals and in aquaculture is limited but does occur. They are, however, important display and food animals. Investigators working on the sea hare, *Aplysia*, were awarded a Nobel Prize for medicine or physiology in 2000.

Key Points:

1. Some species can be quite large and these animals are relatively easy to work with.
2. A number of infectious diseases have been well described in this group.
3. Fractured shells can be repaired with external fixation methods.
4. A number of therapeutic and anesthetic techniques have been described.
5. Some species can be long-lived and may be quite valuable.

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V. Cephalopod Mollusks

There are about 650 species of cephalopods, a group that includes the octopuses, squids, cuttlefish, and the chambered nautilus. This is an important economic group in that they serve as a food source for humans and other animals, are popular display animals, and have been frequently employed in a variety of research projects. Their acute vision, manual dexterity, and intelligence make them fascinating animals to observe and study. Unfortunately, most species are short-lived in the wild and captivity.

Key Points:

1. These are highly visual, intelligent animals that can make good clinical patients.
2. Common problems in captivity include trauma, anorexia, microbial infections, and water quality problems. Recent clinical work includes publications on pharmacokinetics (Gore et al., 2005) and surgery (Harms et al., 2006).
3. Anesthetic and surgical protocols have been established for some species. 4. In Great Britain an IACUC (Institutional Animal Care and Use Committee) application is required to perform research on cephalopods.
5. With their closed circulatory system, these animals make good subjects for pharmacokinetics studies.

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VI. Bivalve Mollusks (Adapted from Levine J, Law M, and Corsin F, Bivalve chapter, *Invertebrate Medicine*, 2006)

This class of mollusks contains many common animals including the clams, mussels, oysters, and scallops. This is an extremely economically important group, especially as a food source for humans. Many species are both captured and cultured for food worldwide. There are more than 10,000 recognized species, found in freshwater, estuarine and marine surface waters. Bivalves fill a critical niche within aquatic ecosystems, the majority functioning as living filters. They comprise a large portion of the shell fauna collected by amateur or professional conchologists on our beaches and freshwater stream banks, and historically have played a significant role in the apparel industry as a source of buttons, or pearls, and as a frequent item on the shelves of novelty shops. Bivalves are popular in display aquariums (private and public aquaria) and as research animals.

Key Points:

1. A number of major bacterial, viral, and protozoal diseases of bivalves have been described.
2. Despite the above statement, knowledge of appropriate chemotherapeutics is minimal.
3. Diagnostic techniques have been described, including antemortem hemolymph collection.
4. Many bivalves can live for decades and as such can be quite valuable.
5. Some species are critically endangered, including a number of freshwater mussels. Veterinarians have already contributed to health assessment efforts on behalf of endangered freshwater bivalves.

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VII. Annelids

The Annelids are a large and diverse group of segmented vermiform animals that are divided into three main classes: the Polychaetes, Oligochaetes, and Hirudineans. All are characterized by regular segmentation of the trunk. It is believed this segmentation evolved as a means of burrowing via peristaltic contractions (Ruppert et al., 2004). Annelids possess a coelomic cavity that is divided into segments by regular septa. The circulatory, excretory, and nervous systems are also segmented. A cuticle covers the animal and segmented setae occur in

nearly all members of the phylum. The mouth is located anteriorly and the anus posteriorly with a straight gut between the two openings (Ruppert et al., 2004).

Key Points:

1. Some polychaetes and oligochaetes have the capacity to regenerate portions of their bodies.
2. Much of the early research on tissue grafting and rejection was performed on earthworms (terrestrial oligochaetes).
3. Virtually nothing is known about the chemotherapeutic treatment of these animals.
4. Very few infectious diseases have been described from this group (except where these animals are the intermediate host for diseases of vertebrates).
5. Some species (tropical marine polychaetes like feather duster and Christmas tree worms) are important and valuable display animals.

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VIII. Crustaceans

The crustaceans are a highly successful class of the Phylum Arthropoda. This group includes the well-known lobsters, crabs, crayfish, shrimp, barnacles, and hermit crabs. Numerous other taxa belong to this class isopods, amphipods, and brine shrimp.

Economically, this is one of the most important groups of invertebrates. Its members are important for food, research, and as display animals.

Key Points:

1. The infectious diseases of the penaeid shrimp (a family of shrimp with economic importance as food animals) have been described in great detail, especially some of the viral and bacterial problems.
2. There is data for some antimicrobial treatment in the literature for economically important groups like panaeid shrimp.
3. There are published protocols for anesthesia and euthanasia for some crustaceans.
4. Funds are available to study the disease of economically important groups like crabs, shrimp, and lobsters.
5. Hemolymph is relatively easy to extract and analyze from animals like lobsters, crabs, and hermit crabs.

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IX. Spiders

This is a huge group of animals (over 30,000 species) that belong to the class Arachnida. Less conspicuous arachnids include the mites, ticks, and scorpions. Numerous texts describe the biology, natural history, and husbandry of these fascinating creatures. Tarantulas (not true spiders) represent an important group of commonly kept arachnids that commonly require medical care.

Key Points:

1. By far the most popular group of "spiders" kept at pets in the home are the tarantulas.
2. Many clinical techniques, including hemolymph collection and anesthesia have been described for tarantulas.
3. Female spiders can be long-lived (several decades) and may be quite valuable.
4. Common clinical problems include trauma, limb autotomy, and dysecdysis.
5. Surgical repair of the fractured exoskeleton is commonly accomplished with surgical adhesives.

Further Reading:

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X. Limulus

Limulus polyphemus, the American horseshoe crab, is actually not a crab at all but a member of the Class Merostomata in the Phylum Chelicerata. Horseshoe crabs are more closely related to arachnids than crustaceans. This is the only species that occurs on our coast (Western Atlantic) but there are other species of horseshoe crabs that occur in Asia. *Limulus* is a very important animal for biomedical research and is used as bait and fertilizer (controversial) as well as being an important display and "touch tank" animal in public aquaria. Investigators examining vision and the *Limulus* lateral eye were awarded the Nobel Prize for medicine or physiology in 1967.

Key Points:

1. The anatomy and physiology of this animal has been thoroughly researched.
2. These animals are easy to handle and work with.
3. Trauma cases can be surgically repaired with external fixators like epoxy.
4. Very little work has been done with regards to chemotherapeutic treatment.
5. These animals make good subjects for pharmacokinetics studies and some papers on pharmacokinetics are now appearing in the literature.

Further Reading:

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XI. Insects

This is by far the largest group of invertebrates and possibly the most economically important. Insects are loved and despised worldwide and occupy nearly all niches except the marine environment. They are important as a human food source in parts of the world and both sustain and destroy agricultural crops, depending on the species of insect and plant.

Key Points:

1. Important research and display animals include beetles, butterflies, grasshoppers, walking sticks, and ants.
2. Much research has focused on the diseases of insects; in some cases to help the insects and in some cases to harm them.
3. Butterfly houses and "arthropod zoos" are very popular at zoological gardens and natural history museums.
4. A fair amount of research has been published on managing infectious diseases of honeybees (which are not native the North America).
5. These animals can be successfully anesthetized prior to a variety of diagnostic procedures.

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XII. Echinoderms

This interesting and diverse group of animals includes the sea stars, brittle stars, sea cucumbers, sea urchins, sea biscuits, and crinoids. Many are commonly displayed in aquaria and used in research. Humans do not consume most species but the gonads of sea urchins are a popular food item in some sushi restaurants.

Key Points:

1. Very little is published with regards to the medicine and surgery of this group.
2. Some species are easy to maintain in captivity, making them popular as "pets" and for research.
3. Some species have regenerative capabilities and generally heal well and quickly. 4. Information on anesthesia and sedation can be found in the basic scientific literature.
5. In some groups the external "test," or skeleton, can make clinical evaluation difficult.

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XIII. Clinical Techniques:

Anesthesia & Analgesia (from: Gunkel and Lewbart, 2007 & 2008)-

Invertebrate anesthesia is still in its infancy and relatively little research has been done to improve the understanding of the various anesthetic agents used for invertebrates. Still, there is a body of work that supports and defines this topic, and key points and references have been included where appropriate. Until more information is available regarding pain perception by invertebrates, an analgesic should be give to any animal that is subjected to a painful procedure, and the amount of stress and pain induced should be reduced by decreasing awareness via appropriate choices of anesthetic agents.

The use of analgesic agents in invertebrate species has its own limitations since very few reports can be found documenting the administration and dosing of analgesics agents, especially in the very small species. Assessment of pain or discomfort in invertebrates is very difficult, despite the fact that some avoidance behavior has been described. The effect of analgesia is even harder to evaluate.

More research is required in this area, but in the meantime, if possible, drugs with analgesic properties should be used to anesthetize invertebrates when invasive procedures are performed to decrease the

nociceptive pathway. Hypothermia and CO_2 do not possess analgesic properties and may even show hyperalgesic characteristics. Inhalant agents are preferred over the latter methods. Although inhalant agents do not possess true analgesic properties, they do render mammalian patients insensible to painful stimuli when administered at sufficient doses. Unfortunately, the insensibility to painful stimuli only lasts as long as the animal is anesthetized, and administration of an analgesic would be advisable if post-operative pain is anticipated.

For a recent review of this topic please refer to Cooper (2011). The complete citation is included with the general references below.

Sample Collection, Preparation, and Evaluation (from: VanWettere and Lewbart, 2007)-

Cytologic samples can be collected, as with vertebrates, by swabbing, scrapping, imprints or fine needle biopsy. One major difference between vertebrates and invertebrates is hemolymph collection. Hemolymph of invertebrates is comparable to the blood of vertebrates. Many invertebrates have an open circulatory system in which hemolymph flows to the organs through arteries, passes into a hemocoelomic cavity, and drains to the heart and respiratory organs through progressively larger venous channels. In most cases, hemolymph is composed of circulating hemocytes, soluble defense molecules, and a respiratory pigment (usually the copper-containing hemocyanin). Hemocytes are considered the equivalent of the vertebrate white blood cells with the additional function of coagulation. Hemolymph is the most readily accessible and often relatively easily antemortem collected tissue and can even be obtained from very small invertebrates such as flies and mosquitoes.

Generally, it is recommended to clean and disinfect the shell and/or integument at the collection site. In species with a hard cuticle, if the bleeding does not stop rapidly after sample collection, closure of the puncture site can be made using cyanocrylate (tissue glue) or a similar adherent material. Anesthesia may be required for sample collection in some species. There is wide variation in the anatomy between different species and description of hemolymph collection sites and details will be presented during the lecture and are accessible via the references.

Imaging-

There are examples of diagnostic imaging being used on invertebrate species and a recent paper on Limulus (see section X) will be reviewed and discussed. Davis et al., (2008) have published a very informative work on imaging a number of terrestrial species with standard and contrast radiography.

Chemotherapeutics-

There have been some recent papers dealing with chemotherapeutics and pharmacokinetics pertaining to invertebrates. Appropriate examples appear in this handout. ***Surgery-***

The literature contains a slowly expanding database of surgical procedures being performed on invertebrates. Some cases with the applicable references have been included and will be reviewed.

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ORNAMENTAL FISH: WATER QUALITY, NATURAL HISTORY, DIAGNOSTIC TECHNIQUES & TREATMENT, DISEASES

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Introduction:

The following notes are a summary of ornamental fish medicine. There is far more material here than will be covered during the lectures or you will be responsible for on the examination. There is also some redundancy in the reference lists at the end of each section.

What are fish?

The group of animals commonly referred to as "fish" is a paraphyletic group of some 35,400 described species (www.fishbase.org; January 8, 2024). That is, it includes all of the descendants of the common ancestor of the vertebrates (subphylum Vertebrata) with the exception of the tetrapods (subclass Tetrapoda--amphibians, reptiles, birds, mammals, totaling around 66,000 species http://www.currentresults.com/Environment-Facts/Plants-Animals/number-species.php, May

13, 2024), a fairly significant branch of the subclass Sarcopterygii alongside lungfish and coelacanths. Included are the hagfish (order Myxiniformes), lampreys (order Petromyzontiformes), sharks, rays and chimaeras (class Chondrichthyes; sharks and rays comprise the subclass Elasmobranchii), the sturgeon and paddlefish (order Acipenseriformes), bowfin (order Amiiformes), gars (order Semionotiformes), and the hugely diverse teleost fish (division Teleostei), which comprise about 96% of extant fishes. For the sake of simplicity, the cartilaginous fish are often referred to simply as elasmobranchs, although this group excludes about 30 species of chimaeras, and the bony fish as teleosts, although the teleosts do not include other ray-finned fish such as gar, bowfin, paddlefish or sturgeon. Care must be taken when speaking inclusively of the whole or parts of the "fish" assemblage.

Tropical fish kept in aquaria include both freshwater and marine species. The vast majority of over 1000 species of fish kept by hobbyists are small freshwater. Marine tanks are more involved to keep and maintain, so numerically tropical marine fish comprise a much smaller portion of the pet fish population, but species diversity is comparable. Greater than 95% of freshwater fish in the pet trade are produced in aquaculture facilities, while the opposite is true for marine fish. Singapore is the world's largest exporter of tropical fish, while in the United States, Florida is the leading tropical fish aquaculture producing area, with much of the industry within an hour's drive of Tampa/St. Petersburg.

Common groups of freshwater fishes kept by hobbyists:

- **Cyprinidae**, the minnows, over 2000 species. Barbs, rasboras, danios, (also carp, koi and goldfish).
- **Osteoglossidae**, bony-tongues, 6 species. Arowanas.
- **Catfishes**, 15 families, over 2000 species. Including Loricaridae(including plecostomus and other "algae eaters", Callichthyidae (including *Corydoras* spp.), Aspredinidae (banjo catfishes), Schilbeidae (glass catfishes).
- **Cichlidae**, cichlids, over 900 species (over 700 from Africa). Extensive adaptive radiation of cichlids in African rift lakes has received considerable study in evolutionary biology. Also includes the South American freshwater angelfish *(Pterophyllum*) and discus (*Symphysodon*).
- **Electrophoridae**, electric eel or electric knifefish, one species. Requires acid water (pH 6), can breathe air.
- **Mormyridae**, elephant fish or elephant-nosed fish, nearly 200 species. Africa, weak electric organ, large cerebellum.
- **Anablepidae**, four-eyes, 16 species. Surface dwellers with two anterior chambers per eye, South America.
- **Labyrinth fishes** (Superorder Anabantoidei, including families Anabantidae, Helostomatidae, Belontiidae, and Osphronemidae), about 80 species. Gouramis, kissing gourami, betta. Anabantoid fishes have a suprabranchial organ called the labyrinth organ used for air breathing.
- **Cobitidae**, the loaches, about 110 species.
- **Characidae**, characins, over 1000 species. Tetras, pacu, piranha. Adipose fin.

Some representative marine fish families:

- **Grammidae**, basslets.
- **Tetraodontidae**, blowfishes
- **Chaetodontidae**, butterflyfishes
- **Pomacanthidae**, angelfishes
- **Pomacentridae**, damselfishes and anemonefishes
- **Balistidae**, filefishes
- **Gobidae**, gobies
- **Serrandidae**, groupers
- **Scorpaenidae**, lionfishes, scorpionfishes • **Zanclidae**, Moorish idol, one species.
- **Scaridae**, parrotfishes
- **Syngnathidae**, seahorses and pipefishes
- **Acanthuridae**, tangs and surgeonfish
- **Balistidae**, triggerfish
- **Ostraciidae**, trunkfishes and boxfishes
- **Labridae**, wrasses

Anatomy and physiology*:

A knowledge of normal anatomy is a prerequisite for practicing fish medicine. Fortunately for us, the vertebrate body plan is fairly well conserved, so much of what you see if fish will be familiar, although

there are some bizarre arrangements of the familiar (e.g. sea horses and flat fish), and many differences in specifics.

- *External anatomy.* Fins: dorsal, pectoral, pelvic, anal, caudal. Skin is thin and glandular with no stratum corneum and minimal subcutaneous layer. Contains taste buds in some species, particularly ictalurid catfish (the "swimming tongue"). Scales originate in dermis from osteogenic cells; when removed, attached epidermis is also lost. Scales are lacking in ictalurids and many eels. The head and lateral line system is a collection of porous sensory neuromasts; arrangement varies by species, most complex around the head.
- *GI.* The bowel is largely as you would expect, although goldfish and carp (koi) lack a defined stomach. Pyloric cecae are present in some species. The pancreas is not distinct grossly in teleosts; pancreatic, tissue may be present in liver, spleen and mesentery. The anus is located far cranial in eels.
- *Respiratory.* Gills are located within the opercular cavity. Gill structure: gill arches supported by bones of branchial skeleton, each with two rows of gill filaments (primary lamellae) bearing secondary lamellae where respiratory exchange takes place. Water flow over the secondary lamellae in counter current to capillary blood flow, resulting in incredibly efficient oxygen extraction. Gills also function in monovalent ion regulation (via specialized chloride cells) and nitrogenous waste excretion. Lungs are present in lungfish. Other air-breathing fish have other specialized respiratory organs, such as the labyrinth organ of anabantoid fish (including gouramis).
- *Endocrine.* The thyroid is diffuse, with follicles surrounding the ventral aorta and branchial arteries. Adrenal tissue is divided between the interrenal organ (equivalent to adrenal cortex) within the cranial kidney, and the suprarenal organ (equivalent to adrenal medulla) dorsal to the cranial kidney. Additional endocrine organs to note: ultimobranchial bodies (calcitonin), corpuscles of Stannius (electrolyte balance).
- *Circulatory.* The heart consists of the sinus venosus, atrium, ventricle, and bulbus arteriosus. Oxygen-poor blood is pumped from the heart through the gill capillaries for oxygenation, then to the dorsal aorta for systemic distribution, and returns via the venous system to the sinus venosus. Four distinct types of renal portal system have been described in fish.
- *Lymphomyeloid/Hematopoiesis.* Fish have no bone marrow or lymph nodes. Hematopoiesis takes place in the cranial kidney. The spleen is the major lymphoid organ; the thymus is indistinct and paired, located under the dorsal edge of the operculum.
- *Urogenital.* The kidneys are located retroperitoneally along the vertebral column, and are divided functionally and to varying degrees physically into cranial (hematopoietic) and caudal (excretory) segments. The kidneys are involved in regulation of divalent ions. The paired gonads are elongated and exhibit substantial seasonal size variation.
- *Other.* The swim bladder is used for buoyancy control in fish that require buoyancy. Some connect with gi tract (physostomes), some do not (physoclists). Some are compartmentalized. Gas gland regulates content. Goldfish, carp, minnows, catfish, and salmonids are physostomous. Centrarchids (bass, sunfish), cichlids, and many marine species are physoclistous.

Clinical Physiology

An understanding of electrolyte and fluid balance is critical to delivery of proper supportive care. Organs involved in electrolyte balance include gills, kidneys, urinary bladder and gut. Disorders of any of these organs, plus skin wounds, can result in osmotic imbalances. Marine fish are hypoosmotic to their

environment, and therefore become dehydrated and benefit from fluid replacement therapy when organs of osmotic homeostasis are impaired. Freshwater fish are hyper-osmotic to their environment, and accumulate water and become edematous when fluid balance is impaired. Freshwater fish also may experience marked decreases in plasma osmolality in the course of a stress response (as with shipping, close confinement). In either case, osmotic stresses in freshwater fish can be ameliorated by addition of 1- 4 parts per thousand (ppt) sea salts to the water. Elasmobranchs are a special case, maintaining plasma osmolality slightly higher than their marine environment, by tolerating high concentrations of urea. As with other heterotherms, metabolic rate of fish depends on environmental temperature. Immune response, drug metabolism, and digestion, among other things, are, therefore, temperature-dependent.

*Clinical anatomy and physiology modified from Stoskopf MK (ed). 1993. Fish Medicine. WB Saunders, Philadelphia; 2010, ART Sciences (Second Edition)

The history:

As with any sick animal a good history can be the clinician's best friend; be sure and obtain a complete one. The clinician will require such important information as: How long has the client owned the fish? How experienced is the client? What and how often are the fish fed? Have any new fish been introduced into the aquarium or pond recently and if so were they quarantined? Have the fish been treated with any medications? Armed with answers to these and other background questions the veterinarian or technician is ready to test the water. Developing/utilizing a medical record form tailored to the fish patient that includes the history and water quality values is recommended.

Water chemistry:

Water chemistry is the most complicated part of aquatic system management and perhaps the most important. It is necessary to understand water chemistry principles in order to successfully diagnose and correct aquarium problems.

Oxygen is the most important life-supporting component found in water. Water contains much less *dissolved* oxygen than air (0.004% in sea water and 21.0% in atmospheric air) and most fish must ventilate a volume of water 10 times that of the air ventilated by a terrestrial animal to obtain the same quantity of oxygen. The amount of oxygen dissolved in a given volume of water depends on four factors: temperature, atmospheric pressure, salinity and the aquatic plants in the system. In water, oxygen is either saturated, supersaturated or undersaturated. With adequate aeration from a good air pump most home aquariums are saturated and contain enough oxygen for the tank residents. Overaerating a tank can result in a condition known commonly as supersaturation or "gas bubble" disease. In this situation, the water is supersaturated with atmospheric air and gasses enter the bloodstream and epithelial tissue of the affected fish. These emboli can kill the fish and the situation must be corrected quickly. The author has observed this problem when the tank temperature is very high (over 90^0 F) and the aquarist tries to compensate for the low oxygen levels by excessively aerating the aquarium. Gas bubble disease is similar to the condition know as the "bends" when nitrogen in the bloodstream of a SCUBA diver comes out of solution. Making temperature control and aeration adjustments will solve this problem. Large subcutaneous emboli may be aspirated with a syringe in some cases.

Under-saturation of aquarium water with oxygen may result in hypoxia and is fatal to fish unless corrective measures are taken. Fish experiencing this condition will commonly appear at the surface gasping for air and hyperventilating. This behavior is called "piping" by aquarists.

As temperature increases the amount of dissolved oxygen decreases. It is interesting to note that water at 4^0 Centigrade contains twice as much dissolved oxygen as water at 40^0 Centigrade. Generally speaking, cold and cool water fishes require more oxygen than warm water fishes. Two other factors to consider are pressure and salinity. As the salinity (salt concentration of the water) increases, the dissolved oxygen decreases. There is less oxygen present in seawater than in an equal volume of freshwater. As the atmospheric pressure decreases, the amount of dissolved oxygen also decreases. Thus, there is more oxygen present in a liter of Raleigh water than there is in a liter of Denver water with all other factors being equal. Aquatic plants and green algae also influence dissolved oxygen. During the day, photosynthesis occurs and aquatic plants give off oxygen. At night these same plants absorb oxygen, and if numerous, can deplete a body of water of available oxygen. This is rarely a problem in the home aquarium.

Tropical fish generally require between 6 and 10 parts per million (ppm) of dissolved oxygen to survive. Most fishes become stressed below 6 ppm. A helpful guideline is 6-8 liters of air per hour for every 3.8 liters (1 gallon) of water in the aquarium. At this rate there will be enough oxygen for the fish, plants and nitrifying bacteria. Most established pet stores carry kits that test for dissolved oxygen if the clinician feels there may be an aeration or oxygen problem in the aquarium.

Many people speak of the importance of pH and its affect on fish health. The actual pH of the water is not nearly as important as how the pH is related to other water chemistry parameters such as ammonia. The pH is simply a measurement of dissolved hydrogen ions in the water (the symbol stands for the logarithm of the reciprocal of the hydrogen ion concentration). Most fish can survive a wide range of pH values as long as changes occur gradually. Marine fish are more sensitive to abrupt changes than freshwater fish and some species are more sensitive than others. When transferring fish from one aquatic system to another the pH values of both systems should be recorded. The normal acclimation process should include a "mixing" of the different water to allow the fish to adjust to the change in water chemistry. This is especially important if the pH gap or difference is greater than 0.5. Changes of less than 0.5 are usually not too stressful for fish but normal mixing and temperature acclimation procedures should still be employed. If the pH gap is large (e.g. 6.0-8.5) then the mixing process should be in small volume increments and for an extended period of time (an hour or more if possible). Since pH is measured on a logarithmic scale, there are 10 times as many hydrogen ions in water with a pH of 6.0 as there are in pH 7.0 water, and 100 times more than water with a pH of 8.0.

In unbuffered aquatic systems there tends to be a gradual lowering of the pH since hydrogen ions are given off when ammonia is oxidized to nitrate by nitrifying bacteria. This is a common occurrence in systems that are heavily loaded with fish. Most freshwater aquariums and ponds are best maintained at a pH of about 7.0 while marine systems benefit from a pH of between 8.0 and

8.5. These values are only meant to be guidelines since certain species have their own requirements. There are a number of commercially available products that will both adjust the pH and buffer the water against pH changes. Sodium bicarbonate (baking soda) can be used to increase the pH of a tank while sodium biphosphate or small quantities of hydrochloric acid may be used to decrease the pH. Anytime one decides to adjust the pH of a system with chemicals these compounds should be added carefully and gradually to avoid drastic pH changes. Experimenting first with water not containing fish, or only a few fish, is always a good idea. The buffering capacity of an aquarium will be discussed under the total alkalinity and hardness section. Aquatic systems that are not well buffered may require the addition of crushed coral, mollusk shells, or other limestone-like materials in order to increase the buffering capacity. These materials can be added to the gravel at the bottom of the aquarium or to the filtration system.

Although there is very little carbon dioxide present in atmospheric air there is a lot in natural water. After CO_2 enters water, a small percentage is hydrated into carbonic acid. A portion of this carbonic acid then dissociates into carbonate and bicarbonate ions that are the primary buffers in freshwater.

Alkalinity can be defined as equivalent calcium carbonate and expresses buffering capacity. Don't confuse alkalinity with the term alkaline, a word used to describe water with a pH value greater than

7.0. While calcium carbonate is the primary buffer in water, borate (H_2BO_4) does account for about 5% of the total alkalinity in seawater. This buffering capacity is primarily dependent on anions (bicarbonate and carbonate) and not on cations (calcium and magnesium).

Hardness represents the total concentration of divalent cations in freshwater and is usually expressed in mg/L calcium carbonate. Calcium and magnesium are the major divalent cations associated with the carbonates (the source of alkalinity). The number of magnesium and calcium cations is frequently similar to the concentration of carbonate and bicarbonate anions. The term carbonate hardness is used to describe this condition. When alkalinity exceeds hardness some of the carbonate and bicarbonate are associated with sodium and/or potassium. When hardness exceeds alkalinity the calcium and magnesium ions are associated with anions other than carbonate and bicarbonate. In most cases freshwater hardness values are higher than alkalinity values.

Soft water (0-60 mg/L) generally has poor buffering capacity while hard water (greater than 180 mg/L) generally is a good buffer. If the hardness is high and the alkalinity is low than the previous statement will not be true. Measuring the dissolved cations in a water sample is usually an accurate but indirect way of determining buffering capacity. A good water quality test kit will be able to measure both total alkalinity and hardness.
Next to oxygen, the nitrogen compounds that are dissolved in the aquarium water are the most important factors affecting the health of fish. Most nitrogen enters a system in the form of fish nitrogenous waste. The cycling of nitrogen is primarily performed by two genera of bacteria, *Nitrosomonas* and *Nitrobacter*. Recent research has shown that other genera of bacteria contribute to nitrification in aquatic systems as well as a group of microorganisms known as the Archaea (Bagchi et al., 2014). These bacteria and the substrate they adhere to are called the biological filter and will be discussed later. Ammonia, nitrite and nitrate are the nitrogen compounds of importance in an aquarium system.

Ammonia found in water is generally either in the toxic unionized form (NH_3) or in the non-toxic ionized form (NH_4^+). The ratio between the two compounds depends on temperature, pressure, salinity and most importantly, pH. The general rule is the higher the pH, the more unionized (harmful) ammonia present. The total ammonia nitrogen (TAN) reading represents both forms of ammonia. A total ammonia measurement of 3.0 ppm would be deadly at a pH of 8.5 in freshwater but relatively harmless at a pH of 6.0 for a few days. Hobbyists and professionals commonly ask at what point should ammonia levels be considered dangerous? The best answer is that any detectable ammonia in an established system is an indicator of a filtering deficiency. Either the filter is inadequate or the biological load is too great for the filter. An elevated ammonia level combined with a low pH may keep the fish alive but the ammonia problem itself needs to be addressed or disease will develop.

Nitrite is an intermediate compound in the nitrogen cycle and is converted to nitrate by a healthy biological filter. In freshwater levels above 1.0 ppm will likely be harmful to the fish. As with terrestrial vertebrates, nitrite forms methemoglobin in the blood resulting in respiratory compromise. Affected fish will show signs of oxygen deprivation by pumping their opercula excessively and "piping" at the surface

for air. Marine tropical fishes are less sensitive to elevated nitrite since the abundant chloride in seawater competes with nitrite for uptake at the gill membrane.

Nitrate is the final nitrogen compound in the nitrogen cycle and is usually not toxic to fish but persistently high levels (over 50 ppm) is probably stressful to some species. Elevated levels in an aquarium may lead to excess algal growth. Regular water changes and nitrogen monitoring will help alleviate this problem.

Introduced toxic compounds:

When evaluating an aquatic system, one should always find out the water source. If the water is from the tap then it should be determined whether it is city or well water. Most municipal water has been chlorinated to disinfect it for safe human consumption. While relatively harmless to humans, chlorine can be deadly to fish. The amount of chlorine in tap water may fluctuate but is usually between 0.5 and 2.0 mg/L (ppm). Chlorine can be "bubbled" out of water if the water is well aerated for several days in a container allowing for a large surface area. While effective, this method is time consuming and some people tend to lose track of time and may introduce fish to water that still contains chlorine. There are a number of commercially available compounds that instantly remove chlorine from tap water. These products usually contain sodium thiosulfate that inactivates chlorine through a chemical reaction in which sodium chloride is formed. Sodium thiosulfate is inexpensive, effective and safe. Just 7 grams of sodium thiosulfate will remove the chlorine from 1000 liters of municipal water (chlorine concentrations as high as 2.0 mg/L).

Another commonly used city water sterilizer is chloramine. This compound combines chlorine with ammonia, both of which are harmful to pet fish. The reasons behind the use of chloramine instead of straight chlorine are centered on human health concerns. Simply bubbling water or letting it stand for a week or more will not remove chloramines. Water containing chloramines must be treated with a dechlorinator like sodium thiosulfate. Your municipal water supply office can provide the interested individual with more information on how the local water has been treated.

A municipality may occasionally add copper sulfate to the drinking water in low concentrations to help control algae. Copper test kits are available in most pet stores. Levels over 0.15 ppm are dangerous to freshwater fish while levels exceeding 0.2 ppm can be harmful to marine fish. The lower the total alkalinity of the water, the more toxic copper is. Invertebrate animals such as (but not limited to) anemones, corals, crabs, shrimp, snails and sea urchins are extremely sensitive to copper. This fact must be considered if copper is being used to control a parasite problem. If high copper concentrations are consistently found in the water a special copper filter may be needed to remove this harmful compound. Copper pipes in a building's plumbing may also be a source of copper in the water.

Temperature Control:

Temperature is one of the easiest parameters to control in an aquatic system yet the beginning hobbyist commonly overlooks it. As a rule, freshwater tropical fishes thrive between 75 and 80 degrees Fahrenheit and marine species prefer slightly warmer temperatures (78-84 degrees Fahrenheit). Certain species of livebearers like guppies do well at room temperature and most goldfish prefer slightly cooler water (room temperature is adequate).

Water Testing:

Obtaining a good and durable test kit that can be purchased for between $200.00 and $500.00 is recommended. Hach Co. (www.hach.com) and LaMotte Chemical (www.lamotte.com) are two reputable manufacturers and suppliers of quality water test kits. The kit that we commonly use performs about 10 different tests and contains an easy to follow instruction booklet. There are also no probes or electrodes to maintain as all tests are colorimetric comparisons or simple titrations (but one can purchase more advanced and expensive kits with a spectrophotometer etc.).

Regardless of test kit you'll want to be able to evaluate the water for dissolved oxygen, temperature, ammonia, nitrite, nitrate, pH, hardness, and total alkalinity.

Filtration:

All successful recirculating systems have at least one type of filter and many have two or more. A filter is just what it says it is; it filters or removes harmful or unwanted components from the water. Several different types of filters will be discussed.

The biological filter is the best and most efficient means of removing ammonia from an aquatic system. This type of filter utilizes nitrification, a natural process that occurs constantly in soil and water. Nitrification involves the conversion of ammonia to nitrate in a two-step process. *Nitrosomonas* oxidizes ammonia to nitrite and *Nitrobacter* oxidizes nitrite to nitrate. Stable populations of these bacteria must exist in the filter for the nitrification process to perform efficiently. There are even more nitrifying bacterial taxa than the two genera listed plus an entire group of organisms called the Archaea. These bacteria require plenty of oxygen and ammonia as a food source. Under normal conditions it takes several weeks for the filter to develop and function adequately. When an aquarist attempts to "rush" the biological filter by loading a tank with fish before the filter is established he or she will likely be confronted with "New Tank Syndrome." This syndrome is responsible for the death of countless pet fish each year. Patience is the key when starting a new system. Begin with a few hardy fish and then gradually add more fish (properly quarantined) over time when the filter becomes established. If an aquarist just has to have a full tank in the absolute shortest period of time, then there are some commercially available biological filter starter solutions that contain nitrification bacterial cultures. Your local pet store merchant can help those interested in these products (while they probably do no harm there impact is likely negligible). The other alternative is some type of chemical filtration that physically removes the nitrogen compounds from the water. Sometimes a simple box filter containing activated carbon may be used to help remove some of the nitrogen load during the first few weeks that the system is operating. Care should be taken not to remove all of the available ammonia and nitrite or else there will be no "food" for the nitrifying bacteria.

There are several different types of biological filters. The first type is the popular undergravel filter. Most of these filters utilize a plastic grid that lies at the bottom of the tank allowing for a small water space beneath it. Several inches of gravel are then placed over the porous plate. Aerated water is pulled through the gravel bed via airlift tubes that are attached to the plastic grid. The bacteria become established on the grid/gravel and the aquarium water is literally pulled through the filter bed exposing the nitrifying bacteria to the nitrogen compounds in the water. A second type of biological filter is termed the wet/dry filter, also called an ammonia tower or trickle filter. With these filters, the bacterial bed is not submerged in water but rather is sprayed with aerated water that passes through the filter bed by means of gravity. These filters are desirable since they tend to allow for a large surface area and consequently many bacteria can colonize the filter and much ammonia can be converted to nitrate. The large municipal sewage treatment plants operate with gigantic versions of the wet/dry biological filter.

Many enterprising aquarists construct their own biological filters; those with less time or mechanical aptitude can buy commercially produced wet/dry filter systems.

A mechanical filter is any type of filtration apparatus that actually strains particulates from the water. These filters usually won't remove particles smaller than 3 microns and thus will not remove ions such as ammonia and nitrite. Submerged box filters, out of tank power filters, sand filters and diatomaceous earth filters all utilize some form of mechanical filtration. Most good recirculating aquarium systems combine mechanical filtration with a biological filter.

The use of activated carbon is the most popular means of chemical filtration in the pet fish hobby. Activated carbon binds organic compounds efficiently and may act as a substitute for a biological filter. When treating a system with antibiotics or other therapeutic agents it is important to discontinue the carbon filter during treatment since the charcoal may remove the medication from the water (do not discontinue aeration).

There are two other types of filtration that have gained popularity in the past decade or so. These are the ultraviolet filter and ozone filter or ozonator. These two filters are commonly used together since ultraviolet light will inactivate ozone that can be harmful to aquatic life. These filters are not usually directly exposed to the aquarium water but rather some of the water from the aquarium is shunted to the filters so that over a period of time all of the water has passed through the filters. When water flows are properly controlled, and the filters are adequately maintained, these filters can remove organics from the water and kill both bacteria and some suspended parasites. Ozone and ultraviolet filters are very expensive and are not common in the home.

Biopsy and other sampling techniques:

In many cases, and especially those dealing with a client's pet fish, the clinician may want to take some tissue samples for examination without killing the fish. Many procedures can be rapidly performed with little risk to the piscine patient. Naturally, larger fish fare better than smaller fish and the overall condition of the animal is also a factor in how it will respond to biopsy techniques.

After ruling out a water quality problem, and suspecting a parasitic or bacterial problem, one should begin with the following simple procedures: The skin scraping, fin clip and in some cases the gill snip. An anesthetic agent such as tricaine methanesulfonate (Finquel®, MS-222) can be used to restrain the fish and make these procedures easier and safer. This particular agent is purchased in a crystalline form and can be used to produce a working stock solution of 10 grams per liter of clean, dechlorinated water. By making dilutions from this stock solution the clinician can accurately formulate safe and effective anesthetic solutions. Each liter of stock solution should be buffered with about 5 grams of baking soda. The stock solution should be stored in a glass bottle away from light at room temperature. When prepared and stored in this manner, the stock solution is good for about 30 days. Final concentrations of between 100 and 150 mg/liter will usually anesthetize most fish within a matter of three to five minutes. Several studies have investigated clove oil as a fish anesthetic. Clove oil is available on an over-the-counter basis at most pharmacies. Eugenol is not completely soluble in water and should be diluted with ethanol at a ratio of 1:10 (clove oil:ethanol) to yield a working stock solution of 100 mg/ml since each ml of clove oil contains approximately 1 gram of drug. Concentrations of between 40 and 120 mg/L are effective in freshwater and marine species and results are comparable to MS-222, except that recovery may be prolonged.

After the fish loses its ability to maintain equilibrium, it is removed from the water, the procedures are performed and the fish is placed in a "recovery" vessel containing clean water and aeration. A coverslip can be used to obtain the skin scraping sample. The coverslip should be firmly drawn across the area to be sampled, making sure that some mucus and epidermal tissue remains on the coverslip. An alternative method is to use a sterile scalpel blade for this procedure. The tissue sample that is now on the tip of the scalpel is then placed on a slide that contains several drops of clean water. After the coverslip is applied, the specimen is ready for microscopic examination. A fin biopsy can be easily obtained using a pair of fine scissors. Slide prepared with drops of water should be close by before samples are taken. Several small pieces of gill tissue can be safely cut away using small suture removing scissors after deflecting the operculum. Care must be taken to only remove a couple millimeters of primary gill lamellae. There is usually some bleeding following this procedure but it should subside quickly.

One concept to keep in mind is that many ectoparasites that affect gill tissue are usually also found on the skin and fins. Treating the parasites on the skin may also take care of the parasites on the gills. Gill damage due to environmental problems (high ammonia, bacterial gill hyperplasia) can only be evaluated after a gill biopsy has been performed.

Obtaining blood samples from tropical fish is challenging but quite possible. It is very difficult to do in fish less than three inches long (if you want the fish to survive). A sterile blood sample is a useful way to culture for a suspected bacteremia or septicemia. Fresh whole mount blood smears can be valuable in diagnosing protozoal blood parasites (e.g. trypanosomes) and in an overwhelming septicemia motile gram negative rods can frequently be observed darting across the microscopic field of view. Stained blood smears will reveal numerous nucleated erythrocytes, leukocytes and thrombocytes. Campbell and Ellis (2007) have published an excellent review of piscine hematology. Some people insert the needle along the lateral line near the tail of the fish and others take a midventral approach, entering the vein from its ventral aspect. Once the needle touches the vertebral spinal body, the needle can be gently “walked” ventrally until it drops into the caudal venous sinus. Slight constant negative pressure on the plunger of the syringe will facilitate sample collection. If a blood sample is necessary from a very small fish and survival is not important in diagnosis (many other fish may be at risk and a necropsy is the best option) the tail can be removed at its base (caudal peduncle) and the small drop of blood which appears can be collected with a clean capillary tube and then placed on a slide.

Performing a fecal examination on a fish is not usually at the top of a list of diagnostic procedures

even though it is a relatively easy and valuable test to perform. If the owner cannot obtain a fecal sample from the bottom of the aquarium, the fish can be placed in water containing tricaine methanesulfonate. Many fish will defecate as they relax in the anesthetic solution. If time is not a factor, the fish can be placed in a plastic bag, clean jar, or small aquarium, and a fecal sample can be collected within a matter of hours in most cases.

One final and very important area of diagnostics involves the field of microbiology. Cultures of skin and gill tissues are not especially helpful due to the ubiquitous nature of aquatic bacterial pathogens. Cultures of clinically healthy fish and clean water will commonly reveal the presence of gram negative bacteria. Clean blood samples are valuable in detecting and identifying septicemia. As with terrestrial animal medicine, every attempt must be made to procure sterile samples for microbiology. A popular culture site in fish is the kidney. The kidneys of fish run just ventral to the spinal column and are generally found the length of the body cavity. Culturing kidney tissue is a postmortem technique that is relatively easy to do. Culture samples may be processed in the clinic and antibiotic sensitivities run. Many small animal clinics are not equipped to perform microbiology testing. Fish cultures can be sent

out of house since many veterinary schools and state agricultural diagnostic laboratories are familiar with fish bacteriology.[10]

Radiology:

Here at NC State radiology is part of many a pet fish diagnostic evaluation. Radiographic findings have been instrumental in diagnosing and treating a number of fish cases. Fish are relatively easy to radiograph. Most can be handled without anesthesia by simply removing the fish from a tank or bucket, placing it on a radiographic plate (protected by a plastic bag), and making the exposure. Fish will even tolerate contrast studies, CT scans, and bone scans (see below).

Ophthalmic examination:

Ophthalmic problems in pet fish are commonly encountered. Diagnostic techniques such as ophthalmoscopic examination, fluoroscein staining of the cornea, and even electroretinography have been utilized to help diagnose ocular disorders of fish.

Computed tomography (CT):

This imaging modality is being utilized for fish diagnostics with more frequency and several publications describe techniques and results (see Further Reading section). As machines become "faster," imaging fish with CT becomes easier and safer since time out of the water is greatly reduced.

Magnetic resonance imaging (MRI):

Although not yet commonly used for imaging pet fish, MRI units have been installed in a number of veterinary schools and referral practices, allowing for better access and consequently more opportunities for pet fish application.

Endoscopy:

This technique is gaining in popularity as more equipment and experienced operators become established. Endoscopy can be minimally invasive (exploring the oral or opercular cavities) or surgically invasive (laparoscopy). More details can be found in the *Further Reading* section and the University of Georgia School of Veterinary Medicine offers a short course on fish endoscopy.

Microbiology:

A very important area of diagnostics involves the field of microbiology. Preparations of suspect lesions and acid-fast staining can help rule out mycobacteriosis. Cultures of skin and gill tissues may not be helpful due to the ubiquitous nature of aquatic bacterial pathogens. Cultures of clinically healthy fish and clean water will likely reveal the presence of Gram-negative bacteria. Clean blood samples are valuable in detecting and identifying septicemia. As with terrestrial animal medicine, every attempt must be made to procure sterile samples for microbiology. A popular culture site in fish is the kidney. The kidneys of most fish run just ventral to the spinal column and are generally found the length of the body cavity. Culturing kidney tissue is a postmortem technique that is relatively easy to do. Culture samples may be processed in the clinic and antibiotic sensitivities run. Many companion animal clinics are not equipped to perform microbiology testing. Fish cultures can be sent "out of house" since many veterinary schools, state agricultural diagnostic laboratories, and private laboratories are familiar with fish bacteriology.

Necropsy procedures:

On some occasions, a full necropsy is the best way to arrive at an accurate diagnosis. Necropsies have several obvious advantages over biopsy procedures. Tissues can be looked at thoroughly and completely. Any and all tissues and organs are available for both gross and histopathological inspection as well as microbiological testing. If possible, the clinician should obtain a moribund fish and quickly euthanatize it for examination. An overdose of tricaine methanesulfonate (over 400 mg/liter for 15 minutes) followed by a rapid cut with a scalpel at the base of the cervical spine will quickly dispatch a fish. A two-step euthanasia is recommended. Other step two methods include intracardiac KCL (10 mEq/kg) or mammalian euthanasia solution (pentobarbital) at 1 mL/kg. Once the fish is dead, the operculum can be removed to expose the gills. Samples can be taken for immediate inspection under the microscope and preserved in 10% neutrally buffered formalin for histopathology. Fish tissues can be preserved and handled like any mammalian biopsy sample. Once the abdominal organs are visible, they may be examined and removed. Small pieces of tissue may be excised, squashed on a slide under a coverslip, and examined under the microscope. This quick and easy procedure may be helpful in diagnosing a parasite problem or a condition such as hepatic lipidosis. Any suspect tissues can be preserved in formalin for histopathology. One helpful aspect of pet fish anatomy is that many animals are relatively small and entire organs or organ systems can be fixed whole in formalin.

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Viral diseases

Several viral diseases have been thoroughly described in freshwater ornamental fishes. The most commonly observed viral disease of tropical fish is called lymphocystis disease. This disease is caused by *Lymphocystivirus*, an iridovirus, which infects connective tissue cells of the fish. The virus induces these cells to undergo extensive hypertrophy until the cells may actually be visible to the naked eye. Affected cells can increase a thousand fold in size. The disease appears to be more common in marine and brackish water fishes. Certain species of freshwater tropical fish like the green terror (*Aequidens rivulatus*) are prone to the disease. Members of the genera *Scatophagus*, *Monodactylus*, and *Changa* are all brackish water fishes that seem predisposed to lymphocystis disease. Stress is almost certainly a factor in this disease since outbreaks are frequently observed following capture and shipping of fishes. Gross lesions appear white and granular and usually are seen on the skin and fins. Occasionally, lesions will be seen in the mouth and on the gills. There is no proven chemotherapeutic treatment. Most cases are self-limiting if the fish is provided with proper water quality and nutrition. Surgery can be performed on affected fish by carefully scraping the hyperplastic fibroblasts clear of the fish with a sterile scalpel or scissors. This procedure should be performed quickly and the patient(s) should receive 5-10 days of topical antibiotic therapy following the surgery. A definitive diagnosis can be made by microscopically examining a scraping of the affected area. The enlarged connective tissue cells will appear circular and in clusters. These cells frequently emit a light orange hue under the microscope.

Spring Viremia of Carp (SVC) is a reportable disease caused by a rhabdovirus (*Rhabdovirus carpio*) frequently referred to as Spring Viremia of Carp Virus (SVCV). Until 2002 SVCV had not been documented in North America and is considered a foreign animal disease (FAD) in the United States. In the summer of 2002 the disease was identified in koi from a North Carolina fish farm; there have been subsequent confirmed cases in other states. Mortality may reach 100% but is frequently much less. Younger fish are more susceptible than older fish and infected fish typically present with abdominal ascites and multiple organ hemorrhages. Transmission is horizontal and most cases occur in the spring or early summer when the water begins to warm. Diagnosis is usually made with viral isolation (from spleen and/or caudal kidney) and/or serum antibody titers. Diagnosis should be confirmed with virus neutralization.[1] The disease is not restricted to koi and actually can affect several carp species and some other cyprinids. All suspect cases should be necropsied and the United States Department of Agriculture (USDA) contacted for proper routing of diagnostic samples. Confirmed cases must be reported to the USDA. A complete summary of the disease and diagnostic procedures can be found on the Office International des Epizooties (OIE) web site listed below in the Reference section. It is important to note that SVCV infected fish may also be suffering from a Gram-negative bacterial infection. Petty et al.[2] provide a detailed summary SVCV and a recent paper by Miller et al.[3] traces the molecular lineage of the disease in the United States. The USDA Animal and Plant Health Inspection Service (APHIS) now requires a permit and veterinary health certificate issued by the exporting country for eight species of fish susceptible to SVC. These species are: bighead carp (*Aristichthys nobilis*), goldfish (*Carassius auratus*), Crucian carp (*Carassius carassius*), grass carp (*Ctenopharyngodon idellus*), common carp, including koi (*Cyprinus carpio*), silver carp (*Hypophthalmichthys molitrix*), sheatfish (*Silurus glanis*), and tench (*Tinca tinca*). These regulations are only a couple years old and details can be found here:

http://www.aphis.usda.gov/import_export/animals/animal_import/marine_import_fish.shtml

Koi herpes virus (KHV) is a disease of koi that is frequently fatal. Koi herpes virus was recently declared a notifiable disease by the O.I.E. For details on this and other notifiable diseases go to: www.oie.int. In the United States the USDA is requesting monthly reporting of cases to the state Veterinary Service Officer. Details regarding the ownership of the koi are not required, there are no sanctions, and currently no requirements for depopulation or disinfection. The virus causes a severe branchitis and the affected

fish literally die of hypoxia. Since 1997, outbreaks of this disease have been reported in many European countries, Israel, Asia (including Japan), South Africa, and the U.S.[4-7] Two references provide excellent reviews of the subject.[7,8] There is a report with encouraging results that a live attenuated vaccine for this disease in koi may be practical.[9] There is also anecdotal evidence that koi "heated" to at least 30 degrees C (86 degrees F) may be resistant to an outbreak since the virus appears restricted to environmental temperatures of 18-26 degrees C (64.486 degrees F).[7] While this heat "therapy" may save the fish, it could produce sub-clinical carriers of the disease. Since the KHV genome has been determined, other vaccination options are being explored.[7] Gross clinical signs include enophthalmia, mottled gills, excessive mucus production, and dermatitis.[6,7] Mortality frequently exceeds 80% and is restricted to carp.[8] Diagnosis is made by virus isolation and confirmed by PCR of the viral isolates. Even without isolation of the virus PCR can be used to detect the DNA of virus in fresh, infected tissues.[6,10] In 2012 the US FDA approved a modified live virus immersion vaccine (Cavoy®, Novartis' www.cavpy.com) but the vaccine was discontinued due to poor acceptance by consumers.

Carp edema virus (CEVD) also known as "Koi Sleepy Disease," is a viral disease of koi observed with increasing frequency. This double-stranded DNA poxvirus may lead to lethargy (hence the sleepy part), anorexia, gill necrosis, and very high mortality, especially in juvenile koi. Most aquatic animal diagnostic labs should be able to rule this disease out with freshly preserved gill tissue.

One of the best ways to prevent the transmission of these two viral diseases is through adequate quarantine and biosecurity protocols. All new koi should be quarantined for a minimum of 30 days before introduction to an established population. Biosecurity, in the form of good hygiene and

proper disinfection procedures, will greatly reduce the spread of these and other infectious diseases of koi.

Tilapia Lake Virus (TiLV). This orthomyxo-like RNA virus was only found in the United States in 2019. It has been previously reported from Africa, Asia, Central America, and South America Mortality can be between 10 and 90%. The disease is not known to affect other fish species or humans (https://www.aphis.usda.gov/animal_health/downloads/import/tilv-ed-notice.pdf).

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Bacterial diseases

Bacterial disease is the most common infectious problem of ornamental fishes. Collectively, only water quality problems exceed bacterial diseases in the area of pet fish morbidity and mortality. The majority of bacterial infections are caused by Gram-negative organisms including the following pathogenic genera: *Aeromonas*, *Citrobacter*, *Edwardsiella*, *Flavobacterium (Flexibacter)*, *Pseudomonas*, *and Vibrio*. *Streptococcus*, a Gram-positive genus, has been shown to cause disease in ornamental fishes. Bacterial organisms may be the primary cause of disease, or they may be secondary invaders, taking advantage of a breach in the fish's integument or compromise of its immune system. The majority of bacterial fish pathogens are natural inhabitants of the aquatic environment, whether freshwater or marine. Nearly every bacterial pathogen of fish is capable of living independently away from the fish host.[1] Virtually any extrinsic stress, including shipping, crowding, poor water quality, and inadequate nutrition, may predispose an ornamental fish to bacterial disease.

Fin and skin necrosis

Fin epithelial necrosis, frequently referred to as bacterial “fin rot,” involves the degeneration and necrosis of the skin and fins due to the presence of pathogenic bacteria. A fresh skin scraping or biopsy will commonly reveal the presence of motile bacterial rods which, when fixed and stained, will usually be Gram-negative. Fish with localized lesions may still be eating, and if they are treated appropriately, generally have a favorable prognosis.

Bacteremia and septicemia

Bacteremia is defined as the presence of bacterial organisms in the bloodstream, while septicemia implies that bacteria are actually present and multiplying within the body. It appears that some fish can harbor bacteria in their blood without ill effect. Fish that are septic will generally be anorectic, lethargic, and depressed. Immediate treatment with antimicrobial agents is warranted, and in most cases, it is

advisable to perform a culture and sensitivity test to identify the pathogen and find a suitable course of antibiotic therapy.

Isolation and identification

The most common tissues collected for bacterial culture and sensitivity in ornamental fish are blood, kidney, liver, and spleen. A sterile blood sample obtained with a syringe via the caudal vein is a good way to test for a bacteremia or septicemia. Certain bacterial pathogens of fish will not grow on standard media, so the interested clinician may have to locate a laboratory that is familiar with the microbiology of fish microorganisms. For a detailed account of this topic the reader is referred to an excellent chapter by GN Frerichs, 1993.

Gram-negative organisms

Aeromonas hydrophila (Motile Aeromonad Disease)

Aeromonas hydrophila complex is probably the most commonly encountered bacterial pathogen of freshwater fishes. Several species of these motile rods may be responsible for Motile Aeromonad Disease (MAD), also know as Motile Aeromonad Septicemia (MAS). In addition to *A. hydrophila*, bacteria which have been implicated in MAD include *A. sobria, A. caviae, and A. veronii.*[3] These are ubiquitous organisms and opportunistic pathogens that take advantage of stressed and immunocompromised fishes. Environmental stresses such as crowding, temperature extremes, poor nutrition, and transport all may predispose fishes to MAD. Affected fish may have areas of petechiation and hemorrhage, abdominal distension, exophthalmia , engorged gill lamellae, and sloughing skin, fins, and scales. Systemic cases frequently result in a hemorrhagic septicemia leading to inflammation and necrosis of gastrointestinal tract, kidney, muscle, and spleen. Fish in the early stages of infection may respond favorably to antibiotic treatment and environmental modification. Any underlying environmental problems that might result in stress on the fish should be corrected immediately. Isolate and remove any clinically infected individuals if possible. Broadspectrum antibiotic treatment should be started without delay if MAD is suspected. Antibiotics of choice include enrofloxacin, trimethoprim-sulfamethoxazole, and amikacin (see next article for dosing information).

Aeromonas salmonicida (Furunculosis)

This disease is particularly common in koi (*Cyprinus carpio)* where it is referred to as “koi ulcerative disease” or simply “ulcer disease.” The causative agent is *Aeromonas salmonicida*, a non-motile rod, and the problem is especially prevalent during the spring and fall months. In the United States, this disease was first described and characterized in goldfish in 1980. Affected fish usually have shallow or deep ulcers somewhere on the body. Other grossly visible signs may include exophthalmia, areas of ecchymosis, and a distended abdomen. There is frequently a history of recent introduction (within the past month) of new fish to the pond or aquarium. When the condition is identified early, and the fish are treated appropriately with antibiotics, the prognosis is fair to good, although surviving fish may have permanent scars. When possible, injectable antibiotic treatment of clinically affected fish, along with oral treatment of other fish in the pond or aquarium, is recommended.

Flavobacterium columnare (Columnaris Disease)

This widely recognized fish pathogen was known as *Flexibacter columnaris* until its name was changed in 1996. In the aquarium industry this disease has been referred to as “cotton wool disease” and a

detailed paper discusses four strains of *F. columnaris* which infected black mollies (*Poecilia sphenops*) and platies (*Xiphophorus maculatus*). The columnaris organism appears to be an opportunistic pathogen. Predisposing factors include crowding, poor water quality, shipping, inadequate nutrition, and parasitic or other bacterial disease. Columnaris is usually restricted to the skin and gill epithelial tissues, although severe infections can become systemic. Affected fish present with a cotton-like mass or plaque on the head, fins, or tail. Areas of hemorrhage frequently rim these lesions. Persistent infections can progress to deep ulcers. Diagnosis is usually based on clinical signs and microscopic examination of the lesions. In most cases, "haystack" or "mushroom" protrusions of bacteria are seen under low to medium magnification. Under higher magnification the flexing bacterial rods are visible at the periphery of the "mushroom." Treatment of this condition includes correcting any underlying water quality problems or stressors in the environment. Antibiotic therapy in the form of a bath treatment can be rewarding but some strains are resistant to certain antimicrobial compounds.

Edwardsiella sp. (Edwardsiellosis)

While edwardsiellosis is a serious problem in the Unites States channel catfish aquaculture industry (*E. ictaluri* is the causative agent for enteric septicemia disease), this genus of Gram-negative bacteria has not been identified as a significant pathogen to ornamental fishes. *E. tarda* is a known pathogen of humans and can lead to a severe enteritis. Ornamental fish can be subclinical carriers of the disease and it is believed they can act as reservoirs for the organism.

Vibrio sp. (Vibriosis)

While primarily a disease of marine fishes, *Vibrio* spp. are also known from freshwater fishes. Most reports in the literature concern wild marine fishes and aquaculture animals affected by nearly ten different *Vibrio* species. Vibriosis in ornamental fishes is uncommonly reported: goldfish (*Carassius auratus*) *V. cholerae* brown shark (*Carcharinus plumbeus*), *V. carchariae* guppy (*Lebistes reticulatus*), *V. anguillarum*. Fish infected with vibriosis will display clinical signs and lesions similar to those seen with *Aeromonas salmonicida*. In fact, some workers refer to vibriosis as "salt water furunculosis."

Gram-positive organisms

Streptococcus sp. (Streptococcosis)

While streptococcosis has been described in numerous species of wild and cultured fishes it is uncommonly reported in ornamental species. One study, based on samples taken from a large Florida tropical fish farm, isolated streptococcal organisms from members of five separate families of fish: characidae, cichlidae, cyprinidae, monodactylidae, and pangasidae. Clinical signs included exophthalmia, aberrant swimming, ocular hemorrhage, and darkened body color. In many cases mortality and morbidity were acute and moderate to heavy. Diagnosis was confirmed by culture of brain and/or kidney tissue. Antibiotic sensitivity testing indicated susceptibility to ampicillin, enrofloxacin, erythromycin, naladixic acid, and oxytetracycline.

Acid-fast organisms

Mycobacterium sp. (Mycobacteriosis)

Mycobacteria are Gram-positive rods that stain acid fast in fresh tissue impression smears and in histologic section. Mycobacteriosis is the most frequently reported bacterial disease of ornamental fishes. Virtually all freshwater and marine fish are susceptible, and one study found *M. marinum* in 97

fish representing 17 different genera. Affected fish frequently have ulcers somewhere on the body. Other grossly visible signs may include exophthalmia, weight loss, subcutaneous masses, and visceral nodules. *M. fortuitum and M. marinum* are the species most frequently isolated. Infected fish with open sores appear to spread the disease horizontally, and subclinical carriers may exist, shedding bacteria in their feces. Frequently, there is a history of chronic morbidity and mortality in the aquarium. Infected fish have, at best, a guarded prognosis. A variety of antibiotics have been used empirically to treat this condition, some with anecdotal success.

There are zoonotic concerns with these bacteria since human beings can become infected. *M. marinum*, *M. fortuitum*, and *M. chelonae* can all infect mammals, including man. *M. marinum* causes most infections in humans with *M. fortuitum* considerably less common and *M. chelonae* reported rarely. Lesions are usually restricted to the appendages and appear as persistent ulcers or granulomas. Antibiotic therapy is usually successful in humans but it may take weeks or months to control the infection. Aquarists with open cuts or sores on their hands and arms should not place these unprotected body parts in an aquarium or handle fish with suspect lesions. Alcohols (ethanol or isopropyl) are excellent and inexpensive disinfectants for *Mycobacterium*. A comprehensive review of this disease in pet fish has been provided by Francis-Floyd and Yanong.

Nocardia asteroides (Nocardiosis)

Nocardiosis has been described in several species of freshwater fishes, including the neon tetra (*Paracheirodon innesi*). Nocardiosis is very similar to mycobacteriosis but not nearly as well understood. Young fish appear more susceptible than older fish, and the disease is usually chronic and sporadic.

Protozoal diseases

The following list provides the correct spellings and a brief description of some important protozoal disease agents of freshwater ornamental fish.

- *Chilodonella*- A ciliated protozoan which can cause high morbidity and mortality among freshwater tropical fishes at the wholesale and fish farming levels of the industry. Attacks skin and gills. Easily identified microscopically by its heart-shaped structure and slow circular motion when not crawling on the surface of the fish. Once diagnosed, this problem is easily treated with formaldehyde, malachite green or salt.
- *Epistylis (Heteropolaria)*- A stalked ciliate that is commonly found in freshwater containing a high organic load. Tends to colonize bottom dwelling fish such as the plecostomus catfish. Lesions appear pale and white in color and resemble a fungal disease. Microscopically, one sees a ciliated crown atop a long stalk that is prone to frequent contractions. Easily treated with formaldehyde however a clean well-filtered tank is the best solution to the problem. This disease is usually not fatal in itself but may open the fish up to secondary bacterial disease.
- *Henneguya*- A sporozoan which presents in the form of small white cysts on the fins and gills of some fish. The cysts contain infective spores. Commonly seen on the dorsal fins of imported *Leporinus* species. Not harmful to the fish. Careful removal by scraping with a scalpel is the best treatment since the parasite is aesthetically undesirable.
- *Hexamita (Spironucleus)*- These flagellated protozoa may cause severe gastrointestinal disease if present in large numbers. Normal inhabitant of fish digestive tract. As an ectoparasite it is

believed to be involved with "Hole in the Head Disease" (Head and Lateral Line Erosion) common to Oscars and other cichlids. Treated effectively with metronidazole.

- *Ichthyobodo*- Formerly (and still commonly) called *Costia*. A flagellated protozoal ectoparasite. A normal inhabitant of fish skin. Poor water quality and other stresses (especially crowding) may allow this normally mutualistic parasite to reproduce rapidly and overwhelm the host. It is responsive to treatment with formaldehyde and malachite green but tougher than most protozoa. Microscopically the protozoa are very small (5-10 microns), move rapidly, and are shaped like small sickles. They may be attached to host tissue or swimming free. Most common in freshwater species of fishes but has been reported from several marine fishes.
- *Ichthyophthirius*- Known commonly simply as "Ich." The largest protozoal parasite of fish and one of the most commonly encountered. Trophozoites may reach 1.0 mm in diameter. Can affect skin, gills or both. Prevention is the best method of control although the parasite is susceptible to a variety of parasiticides including malachite green and formaldehyde.
- *Plistophora*- A microsporidian sporozoan which is the causative agent for true "Neon Tetra Disease." The parasite is not specific to neon tetras and when present will attack the musculature of the affected fish. Infected muscle will contain numerous sporoblasts containing spores. Grossly infected muscle will appear white or pale. Certain bacterial skin diseases will produce similar gross lesions. Such sporozoan infections are usually unresponsive to treatment and diseased fish should be removed from the tank. High mortality is usually associated with this disease.
- *Tetrahymena*- Commonly called "Guppy Killer Disease." A ciliated protozoan that can be free-living or parasitic. Common in crowded conditions and in water containing excessive organic debris. Unaffected by parasiticides because of its ability to burrow deeply into skin of host that ultimately protects parasites from chemotherapeutics. Best method of control is prevention through sound husbandry practices. These pear-shaped protozoa may be present in very large numbers when the infestation is severe.
- *Trichodina*- A disc-shaped ciliate protozoan found on the skin and gills of many fish. Circular rows of denticles and a ciliary girdle give this parasite a unique radial symmetry. Probably not harmful when present in small numbers.

Trematode diseases

Both monogenean and digenean trematodes parasitize tropical fishes. Monogenean parasites including *Dactylogyrus* and *Gyrodactylus* are ectoparasitic and can cause considerable damage to the host when present in high numbers. These parasites possess a multiple hooked attachment organ called an opisthaptor that disrupts the integrity of the host's skin and mucus membranes. These monogeneans can complete their entire life cycle on a single host and in some species the cycle may be as short as 60 hours if all environmental conditions are optimal. Crowding and other stress factors predispose tropical fish to monogenean trematode problems. These parasites are generally resistant to low doses of formaldehyde and even some organophosphates. Most freshwater monogeneans can be killed quickly with a 3 to 5 minute saltwater bath (30-35 parts per thousand). Glacial acetic acid or hydrogen peroxide dips will also kill these parasites. Dosage information is given in the provided articles and references. Praziquantel baths have also proved to be effective in killing some monogenean worms. While expensive, this is a relatively safe treatment when used at a concentration of 10 parts per million for 3 to 6 hours.

The majority of digenean fluke problems appear to be primarily aesthetic in nature among tropical fish. Fish commonly serve as an intermediate host for these parasites that frequently have a complex life cycle. Invertebrates may be the first host and a bird or mammal the primary host. Encysted digeneans

are commonly observed as metacercaria in the skin and underlying tissues of tropical fish. Occasionally these metacercaria are found in the coelomic cavity of tropical fish. Imported silver dollar fish species from South America are commonly infected with metacercaria belonging to the genus *Neascus*. Some fish may have only one or two metacercaria while others may harbor hundreds. This disease will not harm the fish and will not progress unless an appropriate primary host animal consumes the fish. Fish that are affected are sometimes said to have "Salt and Pepper" disease since the cysts become pigmented and the uplifted scales appear especially white or shiny. Another common digenean parasite is *Clinostomum* that is called the "Grub" by fish farmers in Florida. Excysted worms may be more than 5 millimeters long and are

easily visible to the naked eye. If the metacercaria are not too numerous, they can be removed safely with a clean scalpel.

Occasionally, larvae belonging to the genus *Diplostomum* have been found associated with the lens in the eyes of tropical fish. In such cases the lens will become opaque and the fish may be blinded. There is no reported treatment for this disease.

Cestode diseases

Tapeworms are found inhabiting the digestive tract of wild tropical fishes. Diagnosis can be made by fecal examination observing proglottids exiting the vent of a fish, or during necropsy.

Praziquantel can successfully eliminate GI tapeworms in at least some fish species. Infected fish can be bathed in a 2-5 ppm solution for 3 hours with adequate aeration. Tropical fish commonly act as an intermediate host in a cestode's life cycle and encysted tapeworm larvae called procercoids can be found in the coelomic cavity of tropical fishes.

Nematode diseases

Nematodes are common parasites of fish and can be especially abundant in wild species. In some cases the tropical fish is the definitive host and the nematodes will be found in the gastrointestinal tract. In other instances the fish is an intermediate host and the larval nematodes will be seen encysted beneath the skin, in the musculature or in the coelomic cavity. Medical treatment of the larval forms is very difficult because these nematodes are encysted and well protected. Some species of *Eustrongyloides* form large cysts just under the skin of tropical fish and can be removed surgically, especially if the fish is relatively large. As is the case with other encysted larval helminth parasites, the disease will usually not progress unless the fish is eaten by the definitive host. Gastrointestinal nematodes can be observed on necropsy and ova are readily seen on examination of the feces. While the presence of these parasites may not cause a problem in nature, the stresses of captivity and shipping may exacerbate any parasitic problem. Nematodicides such as fenbendazole and piperazine may be incorporated into food in order to successfully treat these problems. The attached articles contain dosage and treatment information.

Crustacean diseases

There are several important crustacean parasites of tropical fish. *Laernea*, known commonly as "anchor worm," is a modified copepod parasite that infects large scaled freshwater tropical and temperate species of fish. This parasite possesses a life cycle that includes microscopic pelagic larval stages that

molt and grow several times before attacking the fish host. On the host the female anchor worm matures and produces two large egg sacs containing hundreds of *Laernea* eggs. This parasite is easily visible to the naked eye and may be more than 2 centimeters in length. They get their name from the attachment organ that is a highly modified structure that resembles the anchor on a ship. This structure is buried in the host's musculature and allows for the invasion of pathogenic bacteria. Plucking the parasites from the fish is warranted and usually results in inflamed areas that heal quickly. Organophosphates and glacial acetic acid dips are successful in treating the problem. The disease is especially common in imported and domestic goldfish.

The other major crustacean parasite is *Argulus*. This branchiuran crustacean is commonly called the "Fish Louse." Fish lice are flattened creatures with a very distinctive shape and appearance. They have a pair of eyespots and are about 5-10 millimeters in length. They move about the skin of a fish very effectively and camouflage themselves well on the host. They suck bodily fluids from the fish via a sharp stiletto that actually injects a small amount of toxin into the fish. These parasites are especially harmful to small fish. *Argulus* also possesses a life cycle with pelagic larval stages so the entire aquarium system may have to be treated with organophosphates to control the disease.

Depending on temperature, the total life cycle takes between 6 and 20 weeks.

A less commonly seen group of crustacean parasites are the isopods. While most isopods are free living, members of the genus *Livoneca* can be parasitic. Terrestrial pill bugs commonly seen under rocks and logs are isopods and the aquatic parasitic forms resemble their land dwelling relatives. While *Argulus* is dorsoventrally compressed, isopods like *Livoneca* are laterally compressed and appear segmented.

Medicating Ornamental Fishes

Certainly one of the most commonly asked questions concerning the practice of pet fish veterinary medicine is, "what drug should I use and what's the dose?" An uncomplicated question with a complex and frequently ambiguous answer. The problem, of course, lies in the lack of sound pharmacokinetic data available and the overwhelming number of species involved. When environmental differences such as temperature, pH, and water hardness are tossed into the equation, selecting a drug and dosing regimen becomes even less objective.

The FDA is currently examining the wide availability of prescription drugs, especially antibiotics (for more information on the FDA and the use of drugs in aquaculture, consult the following Web Address: (https://www.fda.gov/about-fda/fda-organization/center-veterinary-medicine). With the recent passing of the Minor Use and Minor Species (MUMS) Animal Health Act, we are likely to see some dramatic changes in the availability of drugs for use in fish (it is likely that these changes will mean more "approved" drugs). Such measures will necessitate sound pharmacokinetics, efficacy, and safety studies to support clinical use of antimicrobials and other chemotherapeutants in fishes. Relatively little research related to pharmacology has been reported in aquarium fishes. What little information exists is based on clinical efficacy and in-vitro trials using a number of different antimicrobials. An on-line and updated database contains valuable information on pharmacokinetics in fish (Reimschuessel et al., 2005).

The purpose of these notes is to familiarize the reader with the most current pet fish pharmacokinetic information, provide a comprehensive list of drugs and related compounds, and discuss the variables that influence dosing regimens in pet fish.

Dosing Routes:

Due to their aquatic nature, generally small size, and frequently large numbers, a variety of atypical methods are utilized to deliver antibiotics to pet fish. Standard parenteral methods can and commonly are used to dose aquarium fish with antibiotics, but the clinician must also be familiar with the terminology applied to water borne treatments (below):

Routes of Antibiotic Administration for Ornamental Fish:

- Bath- Usually refers to a treatment in which the drug is dissolved in the water in which the fish are swimming. The treatment lasts at least 15 minutes and less than 24 hours. Dosage is normally based on volume of water and not on fish biomass.

- Dip- Refers to a treatment in which the fish is submerged in a particular solution for between 1 second and 15 minutes. Water volumes are usually smaller than those of bath treatments and drug concentrations are frequently higher.

- Flush or Flow Through- Requires constant water flow. Most frequently used in raceways or narrow vats. The chemotherapeutants is added to inflow area and fish are exposed to the drug as it passes over them with the water current. Similar to dip procedure except fish may not have to be removed from their normal holding area.

- Indefinite Bath- Medication is added to aquarium and usually there is no water change or immediate retreatment.

- Injection- The antibiotic is given by injection with the aid of a hypodermic needle and syringe. Routes may be subcutaneous, intradermal, intramuscular, intravenous, and intracoelomic (intraperitoneal).

- Oral- Medication is mixed with the food in order to treat the fish. Usually done by incorporating the drug into a gelatinized food mixture. For larger fish patients, medication can be placed in a chunk of food and then fed or force-fed to the patient.

- Topical- The medication is applied directly to the lesion.

* Remember, before using any drug in the water, discontinue chemical (e.g. carbon) filtration during treatment as this will inactivate the drug. Adequate aeration is also important during any water treatment.

**When antibiotics are used as bath treatments, ideally they should be used daily for 5-7 days. Water changes (at least 50%) should take place between treatments. This protocol is much easier to follow in a home or hospital aquarium than in a pet store or wholesale facility.

Drugs and Dosages:

The majority of the current information on chemotherapeutics used in aquarium fish has been extrapolated from the aquaculture literature. There are a number of reasons for this, most of which revolve around funding for sound pharmacokinetic research. There are currently only three available antibiotics approved for use in fish intended for human consumption (Romet-

30®,Terramycin for Fish®, and, as of October, 2005, Aquaflor®--florfenicol). Much of the literature dealing with antibiotic usage in aquarium fish is empirical and anecdotal. Fortunately, the veterinarian treating aquarium fish can apply current extra label drug use regulations when selecting and initiating antibiotic therapy.

A formulary has not been provided, but, published formularies exist and the reader is encouraged to review current publications on the subject. The following links also provide updated information related to treating fishes:

https://www.fws.gov/fisheries/aadap/home.htm (accessed January 8, 2024)
https://tal.ifas.ufl.edu/resources-and-services/publications/ (accessed January 8, 2024)

STANDARD OF CARE: PET FISH

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Introduction

The keeping of fish as pets is a hobby with a long history. In recent years, particularly during the past decade, ornamental pond fish including koi and goldfish have become increasingly popular in various parts of the world. In fact, more pet fish are kept as pets in the United States than any other single group of animals including dogs, cats, small mammals, birds, and reptiles (AVMA, 1997; PIJAC, 1997). The hobby has also become more sophisticated in recent years and a growing number of veterinarians are gaining clinical experience with pet fish. Until the 1980's, except in rare instances, most of the medical care and husbandry practices were performed by the hobbyists themselves or with the help of the local pet store clerk or aquarium maintenance person. Many of these people are very knowledgeable and conscientious but there are no minimal training standards as there are in the veterinary profession. Additionally, we as veterinarians understand the principles of medicine, surgery, and animal husbandry. The same fundamental disciplines such as critical care, microbiology, parasitology, nutrition, pathology, and surgery that are applied to terrestrial animals can be applied to pet fish.

With regards to the Standard of Care (SOC) for this group of animals, koi, goldfish, and all commonly kept freshwater and marine bony fishes should be included. Sharks and other elasmobranchs, while occasionally kept in the home aquarium, are more frequently managed by aquarium and zoo veterinarians.

As our knowledge of fish diseases, therapeutics and water quality increase, more and more veterinarians will be qualified to responsibly work with these animals. Peer-reviewed articles on the clinical management of pet fish issues now appear in many veterinary journals. Nearly every major veterinary conference includes fish medicine in the program and several veterinary schools now offer continuing education courses on this subject. In addition, a growing number of textbooks and review articles

contain valuable information on pet fish medicine. All veterinarians, even if they have never worked on a fish, have a broad understanding of disease processes, diagnostics, animal husbandry, and chemotherapeutics. The opportunity to apply this knowledge to a client's pet fish problem can be a rewarding experience. Currently, some clinicians report that 10% or more of their income is generated by fish patients.

Minimal Standards
Continuing Education (CE)

Veterinarians treating pet fish should maintain their state licensure(s) and attend at least one CE session focused on fish medicine every other year. It is recommended that fish veterinarians be an active member of the International Association for Aquatic Animal Medicine (IAAAM), American Association of Zoo Veterinarians (AAZV (or both), and the American Veterinary Medical Association (AVMA). The American Fisheries Society (AFS) is an excellent organization and dedicates resources to fish medicine and pathology.

Pet fish veterinarians are also encouraged to join local organizations, such as aquarium and garden pond clubs, and to attend or make presentations when possible.

A number of annual courses and programs (listed below) are available to the interested veterinarian and veterinary student, and while not mandatory, would be a good way to round out one's education.

-Regularly offered Continuing Education Programs:

Advanced Fish Medicine (University of Florida); every other year

*Aquavet® I, II, III (Cornell University)

Diseases of Warmwater Fishes (University of Florida); every other year -Annual Meetings of Note:

AAFV

*AAZV

*Eastern Fish Health Workshop

*IAAAM

*NAVC (VMX)

*Shark Reef Aquatic Animal Medicine Workshop

*WAVMA
*WVC

-Internship Programs (Check VIRMP for updates):

*Mystic Marinelife Aquarium

*National Aquarium in Baltimore

*Florida Aquarium/UFL Tropical Aquaculture Laboratory

*Shedd Aquarium *Aquarium
of the Pacific -Residency Programs:

*North Carolina State University

*University of Florida

*University of Illinois and affiliated Chicago institutions

*Not exclusively fish medicine

Staff training- Many veterinary meetings (NAVC, WVC, AVMA, etc.) regularly offer CE for veterinary technicians. In house training is recommended and can be used to supplement knowledge gained at CE meetings.

Recommended Library (Note: Information is constantly changing and it is imperative to update your library with the current literature)

Textbooks

- Gratzek, JB. 1992 Aquariology: The Science of Fish Health Management. Morris Plains, NJ: Tetra Press, 330 pp.
- Hadfield C, Clayton L. 2022. Clinical Guide to Fish Medicine. Wiley-Blackwell, 610 pp.
- Johnson, EJ: Koi Health and Disease. Johnson Veterinary Services, 3805 Robinson Rd., Marietta, GA 30068, 1997, 141 pp.
- Lewbart, GA. 1998. Self-Assessment Color Review of Ornamental Fish. Iowa State University Press, 192 pp.
- Lewbart GA. 2017. Self-Assessment Color Review of Ornamental Fishes and Aquatic Invertebrates. CRC Press, 247 pp.
- Noga, EJ: Fish Disease: Diagnosis and Treatment, Second Edition. Wiley-Blackwell, 2010, 536 pp.
- Roberts RJ. Fish Pathology, 4th Ed. Wiley, 2012, 592 pp.
- Roberts, H.E. (ed.). Fundamentals of Ornamental Fish Health. Wiley-Blackwell, Ames, IA, 2009, 244 pp.
- Saint-Erne, N. Advanced Koi Care, Erne Enterprises, Glendale, AZ, 2003, 194 pp.
- Sanders, J. 2023. How to Kill Your Koi. Google Books, 136 pp.
- Smith SA. 2019. Fish Diseases & Medicine. CRC Press. 396 pp.
- Smith SA, Harms CA. 2023. Fish. Carpenter's Exotic Animal Formulary, 6th ed., Elsevier, pp. 22-71.
- Spotte S: Captive Seawater Fishes. New York, Lea and Febiger, 1992, 942 pp.
- Stoskopf, MK: Fish Medicine. Philadelphia: W.B. Saunders Company, 1993, 882 pp.
- Stoskopf, M.K. 2010. Fish Medicine (second printing). ART Sciences. *Available for $99 on www.Lulu.com*

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- The Merck Veterinary Manual, 11th Edition, Merck & Co., Inc., National Publishing Co., Philadelphia, PA, 2016. https://www.merckvetmanual.com/
- Treves-Brown KM. Applied Fish Pharmacology. Kluwer Academic Publishers, Dordrecht, The Netherlands, 2000.
- Wildgoose WH (ed): BSAVA Manual of Ornamental Fish, 2nd ed., Gloucester, England, 2001.
- Yanong RPE, Lewbart GA. 2024. The Aquarium Fish Medicine Handbook, CRC Press, Boca Raton, Florida, 274 pp.

Journals

American Journal of Veterinary Research

Diseases of Aquatic Organisms

- Journal of Aquatic Animal Health
- Journal of Fish Diseases
- Journal of the AVMA
- Journal of Zoo and Wildlife Medicine
- Journal of Exotic Pet Medicine.
- Various open access journals (PLoS ONE, PeerJ, Frontiers In….)
- Veterinary Clinics of North America: Exotic Animal Practice.
- Veterinary Record
- Veterinary Record CaseReports

Hospital Physical Plant

Hospitalizing fish patients can be a challenge but will be necessary on occasion. A variety of aquarium support equipment and supplies including tanks, pumps, filters, nets, siphons, heaters, and water conditioners are required. In many situations the owner of the fish can provide some or all of the necessary materials, including conditioned biological filter substrate, for the hospitalized patient. A room or portion of a room dedicated to fish life support is ideal. The majority of equipment and supplies listed below can be used in the hospital and in the field.

Equipment and Supplies (not including most drugs and standard clinic supplies--a more detailed list appears in the Pet Fish Clinic Supplies section of this notebook) *Husbandry*

- Air pumps
- Air tubing
- Assorted plastic totes/sweater boxes
- Assorted glass aquaria
- Assorted sizes of plastic fish bags
- Assorted nets
- Commercial dechlorinator
- Rubberbands
- Sea salt
- Sponge filters

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- Water test kit
- Water sample bottles (plastic, 250 ml)
- 5-gallon bucket(s)

Medical

- Centrifuge
- Complete dissecting kit
- Compound microscope
- Eugenol (clove oil) 1:9 with 95% ethanol (stock approx. 100 mg/ml)
- Fish anesthesia machine
- Gram scale (to 1 kg)
- KG scale (to 10 kg)
- MS-222 (10 mg/ml buffered stock solution)
- Oxygen tank with regulator
- Plastic surgical drapes
- Refractometer
- Sterile surgical pack(s)

Clinical Assessment

A complete history should be taken on each patient or each population of patients.
Fish should be first given a gross "in tank" or "in pond" inspection if appropriate followed by a thorough physical examination.

- In the majority of cases the aquarium or pond water should be tested. An accurate and properly functioning test kit is probably the fish clinician's most valuable diagnostic tool. The basic pet fish diagnostic laboratory must be equipped to test for temperature, ammonia, nitrite, nitrate, pH, dissolved oxygen and total alkalinity. Test kits that measure copper and chlorine are also desirable. Most state diagnostic labs can perform heavy metal and miscellaneous toxin testing. Several companies manufacture test kits that accurately and inexpensively test the appropriate water quality parameters.

Procedures

-The following list of procedures, while not applicable in every case, should be available and the practitioner should be comfortable with utilizing them or alternatively know where/when to refer.

- Anesthesia/sedation
- Cloacal lavage Celiotomy
- Coelomic lavage
- Enucleation
- Eye aspiration
- Fin biopsy
- Gas bladder lavage

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    - Gastric lavage
    - Gill biopsy
    - Intracoelomic (ICe/IP) and intramuscular (IM) injection sites
    - Microbiological sample collection (frequently kidney, spleen, liver)
    - Necropsy
    - Skin biopsy
    - Surgical wound repair
    - Tube-feeding
    - Venipuncture

Drugs (Refer to the Formulary section of this notebook for more details)

There are currently no drugs approved by the FDA for use in pet fish (although a small number are approved for use in fish intended for human consumption) in the United States. Many commonly employed veterinary compounds, including antibiotics, parasiticides, and disinfectants, should be on hand and available for use with pet fish patients. The fish practitioner should also be aware of the wide use of over-the-counter (OTC) drugs by pet fish hobbyists. An effort should be made to learn about these OTC compounds and have a basic understanding of their ingredients and impact on the patient and its environment.

Laboratory support

Fish clinicians should identify a laboratory that is familiar and comfortable handling fish samples, especially those related to clinical pathology and microbiology. In some cases this may require more than one laboratory.

Miscellaneous

With literally hundreds of species kept in captivity from a variety of (sometimes) unrelated families, it is understood that the clinician will not be familiar with every species of fish with which they are presented.

Fish clinicians should:

- Be familiar with zoonoses and be able to speak intelligently to their clients on this topic Cultivate a list of colleagues to share information and seek consultation

Have a thorough understanding of the natural history, anatomy, and physiology of the major groups of pet fishes (eg. goldfish, koi, cichlids, livebearers, anabantoids).

Summary

Fish medicine is a growing and rewarding area of our profession. Many fish owners have strong emotional bonds to their fish and they seek state-of-the science care and support for their sick or injured pets. The fish medicine knowledge base is small compared to that of small animals or even some of the other exotic taxa. All fish practitioners are encouraged to contribute to this base of knowledge, either by publishing their findings or sharing information and discoveries with colleagues. The Fish Practice SOC document is not comprehensive or permanent and will continue to change, grow, and develop over time.

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LATIN AMERICAN VETERINARY CONFERENCE
NAVC
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Eric Garcia

Aproveche Instagram para impulsar su práctica veterinaria

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"Look at Instagram as your opportunity to share exclusive behind the scenes access to your veterinary practice." – *Eric D. Garcia*

The social media sites with the highest traffic in 2017 aren't just getting millions of views; they're receiving *billions of them.* That's right, as of May 2017, Facebook is averaging *almost two billion visitors per month.* The exact figure, according to online source Statista, is 1.94 billion.

When I first started talking about Facebook and using their platform as a focal point in my presentations, they had just broken 500 million users back in 2010-2011. Since then, they've catapulted to the top of the index when it comes to heavy-hitting social networking platforms with the largest global impact, achieving an almost unfathomably large user base in the process.

YouTube comes in second with about one billion monthly visitors, but guess which social media site comes in third? If you guessed, Instagram, you'd be right; coming in on the heels of YouTube with 700 million monthly users.

Instagram however, which centers around posting, liking and commenting on pictures and short video, has a key difference from other social platforms like Facebook and YouTube that I often discuss.

Instagram is a platform that may already extensively showcase your veterinary practice… *even if you've never set up an account.*

In fact, there is a very good chance that your practice is already on Instagram (also known as *Insta* for short) because of geolocation tagging that exists as a major function of the platform. This *location* feature within Instagram, allows people to share and post their location, wherever they are. Check it out for yourself, visit Instagram.com or download the Instagram app. To easily look up your location page, simply type in the name of your practice. You'll see a listing come up, like this one:

This listing at the top with the little pin and your address is the location that Instagram has already created for you.

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Very few practices know that this location listing exists. It's like both Google and Yelp, where the listing was created *for you* by using a database of businesses. The biggest differentiating factor is that, with Instagram location tagging, you can't leave reviews and you can't claim your listing (at this time).

People are social by nature, so when pet owners are sitting in the waiting room, right after the veterinarian leaves the exam room, they might just take out their phone and start posting!

In fact, they probably are.

This is how the conversations about your practice on Instagram starts in the first place. After all, *who can resist a selfie with their beloved pet?*

What this ultimately means for you is that if you haven't started using Instagram to interact and engage with pet owners who are already posting about your veterinary practice, you're missing a major opportunity!

Your veterinary practice can immediately tap into its existing user base by liking and commenting on photos, and by posting your own. This can serve as the perfect opportunity to offer pet care tips, send a quick thank you, offer condolences for a pet whose final moments are posted to Instagram by the pet owner (it happens often) or anything else that truly lets the client know that they are appreciated. If you haven't set up your account yet, it's certainly not too late. Currently, there are close to 6 million posts that use the hashtag #dogsofinsta and almost **55 million** using the hashtag #catsofinsta (yes, let the rivalry continue).

A hashtag, by the way, is just a way to tag your photos. Hashtags categorize or describe the picture or details at hand. So, when I post a picture with Elvis and Penny, tagging #dogsofinsta is an easy way to reach more viewers and gain more likes.

To get started, you'll need a practice owned smartphone (or iPod Touch). Then you'll need to download the Instagram app, even though you can browse photos through the Instagram website, you'll need to have the app downloaded and logged in to post photos or short videos to your own account.

Now, without further ado (and if you promise not to use too many hashtags), let's start using Instagram to interact with pet owners in fun and meaningful ways.

Get started by taking these simple steps:

(1) Download the latest version of the app to avoid bugs and ensure you have the best version possible at your disposal. Make sure you use a practice owned device, and pick a user handle. Your handle is your social media short name and should contain the keywords of your veterinary practice name. My handle is *@EricGarciaFL* and I use it consistently across social media channels to make sure veterinary practices and pet owners can find me easily.

(2) Switch your account to a business profile by following these simple steps (https://www.facebook.com/business/help/502981923235522). This is important because it will unlock a full range of advertising and analytics options that are otherwise

- unavailable. Don't forget to include a bio, your website, your practice phone number and a nice, high-resolution logo.

(3) Now, download the free Perch App (perchapp.com), which will automatically notify you via email and/or push notification when a pet owner or client tags your location on Instagram. Since you can't control whether your veterinary practice is listed or what people post with *their* location tag, the Perch App keeps you a step ahead by notifying you instantly when a post is made.

(4) Finally, it's time to start posting! Look at Instagram as your opportunity to share exclusive behind the scenes access to your veterinary practice. Post compelling pictures of your hard-working team and the occasional selfie to let pet owners know who's behind the camera (as if I needed to convince you to take another selfie!) As long as they sign a photo-release form, you can even post pictures of pet owners and their pets. In general, have fun with it and don't look too surprised when you see new likes flooding in almost instantly after posting! One of the most fun parts of Instagram is the immediate feedback you'll get after a great post.

(5) Finishing touches on a great post can include hashtags that appropriately describe your local area, theme or mood. For example, #Happy #TampaBay #DogsofInsta (with emojis optional) might be the perfect addition to a post with you and your dog's outside on a sunny day.

By creating an Instagram account, converting to a business profile and using Instagram just like pet owners do, you'll tap into something very special. People share photos of their pets and themselves not because they must, but because of the incredible joy that these pets bring and the fun of it all!

The more you tap into this feeling and share this bond with those coming to your practice, tagging pictures and commenting along the way, the more you'll see that your pet family is even bigger than you first thought it was.

Now that's something worth posting about.

Follow me on Instagram at @EricGarciaFL!

Cómo involucrar a los dueños de gatos en el cuidado de por vida

Eric Garcia

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“Time spent with cats is never wasted.” - Sigmund Freud

The unique relationships we form with animals is something of a spiritual experience. The way that they can sense our emotions, or that we can read their moods just by looking at their eyes, all hints at a connection that’s extraordinary.

But despite our love of animals and pets, some are represented constantly across websites, social media channels and presentations, while others are left behind. I’ve found that practices rarely post about cats, both within social media and across their marketing efforts as a whole.

When I’m consulting with veterinary practices across the world, I’m combing through everything I see to get a holistic impression. This includes everything from the learning about marketing materials in their waiting room, to their website, Facebook Page, brochures, etc. I’ve noticed that kittens are sometimes used in picturesque settings (yes, that picture of a basket of kittens in a sun-drenched field is oh so realistic), but cats as a whole are mostly neglected.

While this presents an issue, it also presents an opportunity.

To take a more comprehensive look at this, let’s begin with some impactful data directly from the American Association of Feline Practitioners (AAFP). The AAFP has found that 50% of cat owners report they didn’t seek to own a cat, but instead their cats “found them.” 69% of those responding to the same survey state they paid nothing for their cats.

This means that the majority of cat owners received little to no instruction on proper veterinary care for their cats, so while we’ve bonded with our cats early and often, we may lack professional insights into how to best care for these lovely animals.

I believe that many who own a cat can relate. One day, you’re leaving some extra cat food outside for an occasional visit, and soon enough, you’ve bonded and you’re the proud parent of a cat!

With this being said, where do first time cat owners go to learn more about the best way to care for their new feline friend? Well, of course they turn right to the Internet. While this used to make me cringe a bit (considering the amount of unvetted blogs and forums circulating about), I’m happy to report that an increasing number of online searches tend to endorse quality information that the majority of veterinarians would recommend.

This is thrilling for somebody like me, who loves when proud pet owners have access to the information they need! This being said, the Internet (I won’t call out any specific social media network by name…except for YouTube) is still absolutely ripe with horrible advice on cat care.

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As veterinary professionals, it's up to us to represent all sorts of pets and to provide equal representation. This is also effective for marketing to more people, and for showcasing our commitment to all species of animals we care for. I challenge you to become more pro-active about sharing the stories of cats in your practice to ensure they are properly represented.

You can start off small, by sharing just a few pictures or an anecdote. During my routine social media audits (a process that helps me quickly hone-in on the strengths and weaknesses of existing social media strategy) I actually look to see the last time your practice shared content about a cat. Content that I routinely audit looks a lot like this:

- Dog Post (Monday)
- Dog Post (Tuesday)
- Dog Post (Wednesday)
- Dog Post (Thursday)
- Dog Post (Friday)
- Cat Post (Saturday)
- Dog Post (Sunday)

You get the picture. Not only does this content become redundant, but it underrepresents two specific groups: cats and consequently, cat owners. I'd like to see certain themes that show more interest in cats, like "Featured Feline Friday," which gives practices the chance to share something about cats that will resonate with cat owners directly on an on-going basis.

Looking again at some crucial data from the AAFP, their statistics show that 51% of clients believe cats are "low-maintenance" while a whopping 70% do not believe that cats regularly hide symptoms. 81%, yes 81% of cat owners in this poll believe that their cats are in excellent health and are self-sufficient.

Now we're beginning to see that the underrepresentation also creates an environment where misinformation can too easily spread and become the "norm" of what's largely believed. I'm confident when I say that it's rare to find a veterinarian who believes that cats don't hide symptoms! A lot of this misinformation comes from pet owners going to the wrong sources for info, like a pet store employee or their local Facebook group instead of a tried-and-true veterinary professional.

The AAFP also notes that "veterinarians estimate that 50% of cat owners consider a trip to the veterinarian to be stressful, versus 20% of dogs." ***Now we've got a scenario where cat owners don't believe their cats hide illnesses and also believe their cat hates going to the vet.***

Do we see a troubling trend emerging here?

Yes! So how do we overcome it?

What's the best way to inform pet owners that cats do indeed hide illness and that yes, our veterinary practice can provide care that truly accommodates the needs of their feline friend?

We need to tell the stories of the cats we see in our practices! Not just telling but showing too. These narratives are crucial to connecting to the hearts and minds of pet owners!

Read on to learn how to tell these stories and how to adhere to industry-standard best practices along the way:

Remember first and foremost, permission is required from a cat's owner and/or caregiver before sharing any of their information. This consent must be written.

(1) Find a cat you've seen recently at your practice.

(2) Secure written permission to share a story about the cat.

(3) Briefly, gather information including the following:

a.) What illness was the cat brought in for?

b.) How did you help to discover the cat was ill?

c.) How did you help to treat this cat from a veterinary perspective?

d.) How is this cat doing today?

When you combine these elements, you're ready to begin telling the story itself, which may look something like this:

Example:

Gazpacho, a 4-year-old calico, came into All Animal Clinic, a Cat Friendly Practice®, after her caregiver, Emily, noticed that she had not been eating a lot lately, and had started hissing and avoiding being petted. Dr. Gray carefully examined Gazpacho using feline-friendly handling and discovered that she had severe dental issues. So, we worked with Emily to take care of Gazpacho's painful mouth. While we had to do a few tooth extractions, we were also able to clean and do preventive treatments. After a short recovery time, we are happy to report that Gazpacho is feeling much better. She is eating well again and since she is no longer in pain, she is no longer hissing or avoiding being petted. Keep your cat's mouth healthy and pain free with regular check-ups at All Animal Clinic. Our staff use gentle, feline-friendly handling to help keep your cat calm.

Why is this story so impactful? Again, let's look at the data! According to the AAFP, 56% of clients report that they would bring their cat to the veterinarian more frequently if they knew this could prevent problems!

This data shows us that increased information, including storytelling and specific examples, would likely lead to increased engagement from cat owners.

To take things even a step further, I recommend that practices consider becoming a Cat Friendly Certified Practice, which really takes the commitment to delivering remarkable feline care to the next level. While I'm not a veterinarian, I know there's more we can be doing to create a better experience for cats.

I also think it's equally important (whether you decide to become certified or not) to proactively share the things your practice does to make visits for cats easier.

This could mean using pheromone diffusers or sprays to create comfort for a cat while explaining how this works and why it's important. Then and only then can you show me the cat cuddled up and content inside a blanket!

The same goes for sprinkling cat nip on a blanket in the exam room. Explain to me that cats prefer a blanket over a cold, sterile table and that the cat nip is just the icing on the cake to enhance the experience further. Do you use feline-friendly handing techniques or have a cat friendly waiting area? Great, tell me more and show me too with pictures or even video!

Without this type of content being shared regularly both via social media and on your veterinary practice's website, getting cats to come back to your practice is a lost cause.

But if you're willing to engage in thoughtful ways and go the extra mile to care for these beloved felines, well, they'll be beating a path to your door in no time at all.

Share your story, and the rest will follow.

TELL YOUR STORY

People are often under the impression that social media is only for peer-to-peer interactions. This, however, couldn't be further from the truth. Facebook is a platform that's become as universal as the water cooler itself. Successful veterinary practices around the *world leverage Facebook as a place to tell their unique story.* Your veterinary practice has a story and details that make it entirely unique: the year it was founded; your founder (or two, or more); your **Cat Friendly Practice®** designation; and your practice style and perspective.

Use social media to tell your story! It is a perfect platform where you can capture and captivate your audience. Tell your followers about success stories at your practice such as:

- How and why you chose to become a **Cat Friendly Practice®?**
- How being a **Cat Friendly Practice®** has improved visits for cats and their caregivers?
- What differences your practice has made today in the lives of cats and other animals?

Sharing this kind of information with your followers in a story format fosters community, trust, interactions, and keeps your trusted cat clients coming back to you. Stories like these are also known as:

Case studies – a story particular to a specific cat client, place, and time.

Case studies are crucially important for a variety of reasons, but primarily to help your audience know about the stellar care your **Cat Friendly Practice®** provides!

When you are creating your case study, be sure to provide your audience with:

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- The reason the cat came in to receive veterinary care.
- Details regarding the type of care you provided for the cat.
- How being a **Cat Friendly Practice®** improved the veterinary visit and overall care for the cat and the caregiver.
- An update on how the cat is doing today.
- A photo, or quick video of the pet.

When you provide this level of in-depth information on a cat, you tell the story of your patient and demonstrate that you can deliver the same quality of care to any prospective client. You can to forge an immediate bond with cat caregivers who appreciate your attention to detail, and the accountability needed to provide optimal care for their cat.

Your followers and their friends want to hear of your successes, which will brighten their day and instill them with confidence about your **Cat Friendly Practice®.** In exceptional circumstances, news coverage has even come about after particularly sincere and uplifting stories. This results in tremendous positive publicity, and simultaneously helps you to market your services to a wider audience. This wider audience can soon grow and enhance your veterinary practice online, and in your local community.

Case studies are also a great opportunity to educate your clients. By highlighting a particular health concern (like lily toxicity in cats), you can spread important information in your success story that will resonate with cat caregivers. These posts can be timed for specific times of year (the “chocolate holidays,” the start of flea season, holiday dangers) to help your clients stay aware of how to best care for their cat, and to keep your practice at the top of their minds.

GET PERMISSION

Yes, you should receive permission from the cat caregiver to share their story, pictures, or a video of their cat on social media or elsewhere. This is an important thing to note and emphasize, as some members of your staff may be appointed to collect signed photo/video release forms, to ensure that you’re permitted explicitly to share various types of media.

Most cat caregivers don’t hesitate at the opportunity to share the joy of their cat with the world and online but receiving permission firsthand is definitely a must.

Sample topics for case studies can include:

- Dermatology: Before and after skin cases
- Dental: Before and after dental care with photos
- Surgical Case Examples
- Laser Therapy Cases

By using Facebook with photos and videos to create and communicate compelling stories, you can enhance your marketing efforts, stay on the cutting edge, and attract more clients to your **Cat Friendly Practice®.**

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APPRECIATE CAT OWNERS

In a world that's moving so quickly, who really has the time to say "please" *and* "thank you"? We might think that our world is so filled with stimuli, that nobody would hear it if we said, "Thank you", just a little more often.

It may feel like these tiny, syllable-sized gestures are antiquated or meaningless in our modern-day environment. However, this couldn't be further from the truth. In fact, those precious two little words might be more important now than ever before. Scarcity solicits demand, right? As **Cat Friendly Practices®,** we might be busier than ever before, but our need to express gratitude is also more prominent than ever.

Our need to express a heartfelt, "Thank you", has never been more relevant or imperative, than it is right now.

Despite what you might have been told, this simple phrase is emblematic of a whole lot more. It can make or break a friendship or even a relationship with one of your clients. In feline medicine, we are so intent on acquiring new business, that often times we do not designate enough attention to telling our existing clients how much we appreciate them, or thank them for coming in. Now, why would we work so hard to build our **Cat Friendly Practice®**, market effectively, and provide stellar service, only to stop short of giving thanks to our clients?

With a few simple phrases you can help retain your clients, but even more importantly, create an ongoing, genuine bond of solidarity and trust. I recommend that you make saying the following few sentences a habit. You'll thank me later:

"Thank you for bringing your cat in to see us. Thank you for being a wonderful cat caregiver, and most of all, thank you for choosing to trust our ***Cat Friendly Practice®*** *with your cat's health care needs."*

This type of response to a new or established client may only take seconds to say but can make a world of difference. Of course, it's got to be genuine, even when you're busy and the phone is ringing again. You can't overlook the importance of sincere gratitude as a cornerstone of building any healthy relationship.

The central point here is this; *the effort really matters, because we really matter.* Simply taking time out of each day to thank your clients and letting them know explicitly of your appreciation and their importance can be surprisingly rare.

I used to work closely with a widely respected veterinarian, Dr. Eddie Garcia (no relation, I promise) who would call each and every one of his clients within 72 hours of their initial visit. He would do this with no ulterior motive or hidden reasoning. He would simply call to say, "Thank you for visiting our practice. If there is anything, we can do for you, we are only a phone call away." He strongly encouraged both positive and negative feedback, in whatever form it came. He would use this feedback to learn about the wants, needs and fears of his clients, and thank them for it - even if their visit was sub-par, as well. I can hear you asking, "Wouldn't this level of openness leave him vulnerable to hours of time-consuming critique?" While that's a fair question, the kicker is this:

- *A majority of phone calls were left on an answering machine (well, voicemail box nowadays).*
- *People were so excited about the calls that they called him back simply to express their gratitude.*

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- *Dr. Garcia boasted a 90% success rate of retaining upset or displeased clients*.

I watched Dr. Eddie Garcia make these types of phone calls every day for over 10 years (watch him in action). *Yes*, he really made these calls each and every day, and *yes*, they really did make a difference.

Calling both new and existing clients is equally important and can't be emphasized enough.

Whereas most of the time clients might simply express their grievance or general feedback to a spouse (if anyone at all), Dr. Garcia used their direct feedback to forge a bond, improve his practice, and retain his clients in a single call. You can do the same.

When I used to ask Dr. Garcia what motivated him to go above and beyond to make these phone calls, he had quite a simple explanation: to stay true to his mission. In his mission, he outlined that his veterinary practice, "will meet and exceed expectation". These phone calls were his little way of making sure that he exceeded his client's expectations of what an attentive and caring veterinarian looked like. And it did.

From phone calls to automated "Thank You" emails, there are plenty of ways to effectively implement gratitude into your **Cat Friendly Practice**®. Here is a 3-step-solution to implementing 'Thank You' into your practice today:

3 Steps to Saying Thank You at your Cat Friendly Practice®

(1) Implement a protocol to have your team members print two reports at some point, consistently, each day. These should consist of two parts:

1) New client report from the day before.
2) Appointment schedule report from the day before.

(2) Decide in your practice who the appropriate person is to make the call. I usually recommend that associates call their own clients in order to create a genuine bond. If associates do not have the time to do so, the practice owner or medical director may make the call. I've recently heard the idea of practices delegating this responsibility to a receptionist or technician. The reason they do this is because they've expressed that cat caregivers are more likely to share a negative experience with the receptionist vs. the owner or associate. Choose the person who you feel would be great at taking on this type of task.

(3) Begin by calling all new clients and only choosing 3-5 existing clients from the appointment schedule report from the previous day. You don't need to call back every existing client to say thanks but spot-check and call a few.

**Optional Recommended Step*

You may also choose to include an automated 'Thank you' email to supplement the phone calls. This email can add a wonderful touch to a follow-up phone call and coincides with my line of thinking:

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You can never be too thankful.

I hope that these tips will help you implement new and improved techniques for your cat caregiver experience now and into the future.

Consigue que los clientes digan que sí a tus recomendaciones! Cómo construir una estrategia de contenido atractiva

Eric Garcia
Simply Done Tech Solutions, LLC
Tampa, Florida, USA

TELL YOUR STORY

People are often under the impression that Facebook is solely about peer-to-peer interactions. This, however, couldn't be further from the truth. Facebook is a platform that's become as universal as the water cooler itself. Successful veterinary practices around the *world leverage Facebook as a place to tell their unique story.* Your veterinary practice has a narrative; a year it was founded, a founder (or two, or more) and a style and perspective that makes it entirely unique.

Use Facebook to tell your story and not only capture, but captivate your audience!

Tell us about your success stories: the pets that you care for and the difference that you've made today. All of these things foster community, trust, interactions, and keep your trusted pet owners coming back for more.

These success stories are technically known as:

Case studies – a story particular to a specific pet, place and time.

These case studies are of crucial importance for a multitude of reasons, but primarily because they help your audience to see firsthand the type of stellar care that your veterinary practice provides!

In a particular case study, be sure to provide your audience with:

- Why the pet came in to receive veterinary care
- What you did to provide care for the pet
- How the pet is doing today
- A photo, or quick video of the pet!

By providing this level of in-depth information on a pet, you tell the story of your patient and ensure that you can deliver the same quality of care to any prospective pet owner who needs it. You'll be able to forge an immediate bond with pet owners who appreciate your attention to detail, and the accountability needed to provide optimal care for a pet.

People want to hear of your successes, which will brighten their day and instill them with confidence about your veterinary practice. In exceptional circumstances, news coverage has even come about after particularly sincere and uplifting pet stories. This results in absolutely tremendous publicity, and simultaneously helps you to market your services to a wider audience. This wider audience can soon grow and enhance your veterinary practice online, and in the local community.
Case studies are also a great opportunity to educate your clients. By highlighting a particular toxicity (like xylitol, grapes, or lily toxicity in a cat) you can spread the important information in a success story that will resonate with pet owners. These posts can be timed for specific times of year (the "chocolate holidays", the start of flea season, holiday dangers) to help your clients stay aware of how to best care for their pet, and to keep your practice at top of mind.

GET PERMISSION

Yes, you should receive permission from a pet owner to share their story, pictures or a video of their pet on Social Media or elsewhere. This is an important thing to note and emphasize, as some members of your staff may be appointed to collect signed *Photo/Video Release Forms*, to ensure that you're permitted explicitly to share various types of media.
Most pet owners don't hesitate at the opportunity to share the joy of their pet with the world and online, but *receiving permission firsthand is definitely a must.*
Sample topics for case studies can include:

- **Dermatology:** Before and After Skin Cases
- **Dental:** Before and After Dental Care (Photo)
- **Surgical Case Examples**
- **Laser Therapy Cases** (Pets can often improve a limp in a matter of weeks after laser therapy)

By using Facebook, photos, and videos to create and communicate compelling stories, you can enhance your marketing efforts, stay on the cutting edge, and attract more pet owners to your veterinary practice.

About the Author: Eric Garcia is an IT expert. Digital marketer. Industry thought leader. When it comes to helping veterinary practices streamline their technology and attract and retain clients, Eric Garcia has a proven track record of educating the industry and producing results. Eric is an IT and Digital Marketing consultant working exclusively with veterinary practices. In addition to a long list of satisfied clients, Garcia's work has been recognized throughout the industry. He speaks regularly at conferences all throughout the world. **Facebook:** facebook.com/EricGarciaFL **Instagram:** @EricGarciaFL

Puedes ayudar con mi aullido?!:cómo manejar a los haters, bullies y más en línea

Eric Garcia

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Tampa, Florida, USA

As with most industries over the past few decades, the veterinary field has gone virtual — and with benefits ranging from online pharmacies to simpler appointment scheduling and telehealth visits, to online advertising, and of course, greater access to client feedback thanks to social media, there's a lot to be grateful for.

But this level of access also leads to much simpler (and more anonymous options) for leaving hate. Negative comments or constructive criticism is one thing: cyberbullying is another.

20% of the American Veterinary Medical Association (AVMA) members have reported encountering some form of cyberbullying from vicious reviews to threats of physical harm.

As a world and as a profession, we've forgotten the Golden Rule, and it's time we face this problem before it causes any more harm to our field.

Here are some tips I shared at the virtual 2020 PSIvet Business Symposium, to help you determine what you should do if you or your practice start to encounter online harassment:

● **Leave private hate private.** Facebook groups and other niche forums can both bring about a great sense of community and (unfortunately) an even greater sense of entitlement. It's amazing what people feel confident to say with their real photos and names attached to their profiles — and it only gets worse when there's greater anonymity. Somehow typing a rude response feels like less of a risk than insulting someone in person, but whether you feel tempted to argue their point or defend your practice on any of these forums you're better off leaving it alone. They did not write this comment to you — you are not going to change their mind. You're better off leaving the debate to other people within the private group - and chances are they'll move onto another topic by the time you've formulated your response anyway. The more attention you give the hate (through comments or replies) the more you can unintentionally add fuel to an already dying flame.

● **Take a moment before engaging with negative reviews.** When a client has lashed out online, you are better off giving them anywhere from 24-72 hours to cool down before you reach out personally. This means pulling out their pet's medical records, picking up the phone, and seeing what you can do to help them in person first, before settling for responding to their comment online. If they are unavailable, then your first step is to publicly apologize for their experience and note that you haven't been able to get a hold of them. This way they (and anyone else who sees the

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negative comment) will know that you and your practice are trying to make things right. Apologizing isn't about admitting that you or your practice is in the wrong: it's about expressing empathy and acknowledging the client's perspective — you cannot fix a situation without first acknowledging their feelings. Although it's tempting to share your side of the story in your apology, avoid discussing anything about their pet's case online — especially if it's on a public forum. There is still client confidentiality at risk, and you could get reported to your state board. Yikes.

> **Sample Reply to a Negative Review**
>
> "We're sorry for your experience. We have not been able to reach you by phone. We would like to make this situation right with you. Please call our medical director at (xxx) xxx-xxxx."

● **Report slander and false reviews.** There's a difference between an angry (but honest) client review and a false one. The good news is that with Google and Yelp and other public reviews, there are actual guidelines in order to protect businesses like yours. If a review is fake, false or misleading, or otherwise in violation of the review's host site, you can send requests for their removal and get them taken down.

Here are some simple steps you can take to get false reviews taken off Google and Yelp:

Google

- Log into Google My Business at **google.com/business.**
- Select "Reviews" from the menu.
- Find the review in question. Click the 3-dot menu, then select "Flag as inappropriate."

Yelp

- Claim your business page at **biz.yelp.com**.
- Locate the review in the "Reviews" section of your business account.
- Click the 3 dots and click "Report Review."
- Choose the reason for removal from the dropdown list.
    - Grounds include containing false information, threats, lewdness or hate speech, not describing a personal customer experience, and being posted by a competitor or ex-employee.

● **Overwhelmed? You don't have to go it alone.** It can be emotionally draining and generally exhausting to find yourself and your place of work under attack. The good news is that AVMA has its own cyberbullying hotline to help veterinary professionals of all types with immediate support and a free counseling session to help get your practice's reputation back to what it used to be. Simply call (626) 531-1140, and you'll have a safe space to discuss your concerns and your side of the story without ticking anyone off or violating confidentiality guidelines.

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● **Stop vet-on-vet harassment.** Unfortunately, not all cyberbullying comes from clients. Whether it's coming from competitions veterinarians or unhappy staff, veterinary professionals should know better than engaging in unnecessary online harassment campaigns — especially when they consider that the veterinary field is already a profession that is prone to suicide. When you have a problem with another vet, you can do much better than calling each other out in negative ways on social media. We all have bad days: venting to a friend is a much better idea than spilling all of your problems on Twitter or Instagram. And if you're upset about something unfair or unjust happening in your profession, write to your state board or national governing bodies, or write an article or create a series of podcasts — make something positive for change instead of giving into simply complaining for sympathy points or petty revenge.

● **And finally, skip social media with your breakfast.** One of the number one rules of the internet is "don't read the comments" but you can extend that to mindless scrolling on social media, too. Of course, as a business, you do need to respond to legitimate criticism and reviews but if you want to be happier, start your day without checking social media. You'll be glad you did.

About the Author: Eric Garcia is an IT expert. Digital marketer. Industry thought leader. When it comes to helping veterinary practices streamline their technology and attract and retain clients, Eric Garcia has a proven track record of educating the industry and producing results. Eric is an IT and Digital Marketing consultant working exclusively with veterinary practices. In addition to a long list of satisfied clients, Garcia's work has been recognized throughout the industry. He speaks regularly at conferences all throughout the world. **Facebook:** facebook.com/EricGarciaFL **Instagram:** @EricGarciaFL

Ya programó su próxima cita? construir estrategias de retención de clients

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THE DIGITAL MARKETING REVOLUTION HAS ARRIVED

The days of print-heavy advertising dominated advertising campaigns are over. The old scenario used to mean creating an advertisement that was clean, clear and direct; paying a lump sum or quarterly fee to get the ad in circulation and hoping for a successful campaign that picks up business in some way or another. If you wanted to get fancy with it, you could target a few specific locations with growing populations, or take out a double-page advertisement to ensure your advertisement was as visible as possible.
Now, physical advertisements are sometimes looked at as cumbersome by newer consumers and younger demographics, while more people are using their iPhones and computers to shop and search for businesses and new products each day.

While print media still plays a role, more and more consumers and clientele are adapting to the digital world and moving their attention to Google, Facebook, Instagram and the web as a whole.

This means that if you're still using the same techniques for marketing that you were a few years ago, you may be missing out on a huge array of new clients! These potential clients aren't hiding; they're just waiting to be attracted by the right advertisement or promotion to bring them in! More often than not, you can target these new clients effectively by using the right approaches to marketing on the web.

In fact, popular search engines like Google, along with your veterinary practice's website, are the two primary sources of New Client Referrals. This is a trend that doesn't seem to be slowing down anytime soon and is impacting the way that successful veterinary practices do business.

The good news is that even if you did have success with older forms of marketing, the room for you to grow and capitalize on new techniques is greater than ever. There are tools in place to ensure that your marketing is as effective as possible, and that your Return On Investment (ROI) is robust enough to ensure that the campaigns are worthwhile. When it comes to measuring the performance of digital marketing campaigns, your techniques can be boiled down to a science, where the better the execution and measurement, the more success you'll have.

Here are some proven tips and tools that can enhance your current marketing efforts and ensure that you have the right tools in place to have profoundly successful campaigns when it comes to marketing your veterinary practice:

TIPS & TOOLS FOR SUCCESS

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It's important to ensure that your client management software doesn't count "no show" clients as new clients. Why? This can throw off your measurement of revenue and growth, when the best digital marketing campaigns will only use data that's truly effecting your veterinary practice.

I recommend looking at New Client Revenue as opposed to just looking at New Client Numbers. After all, it's the revenue that these clients generate within the first twelve months of doing business with a veterinary practice that will help to determine if the veterinary practice has received return on the respective marketing tools used. Unless a certain amount of revenue and return is reached, you won't be able to justify certain marketing channels that may be consuming more resources than they are generating, or are keeping your margins paper-thin.

Additionally, you have to be diligent about making sure that the figures reflected in your software are true to what's occurring day to day. For example, sometimes your management software might say that you've received a new client, when in reality you have not! This can commonly occur when an account is created for a client in advance of their appointment, but the client cancels or is a no show. If this occurs, you should make the adjustments to reflect the most accurate information possible. A simple error during this stage can throw off your projections for revenue and your new client data as a whole.

ENSURING YOUR RETURN

It's important to have certain parameters in place to ensure that your efforts are a success. If you spend $500 USD on a campaign and it returns $750 USD, is this considered a success? What about the time and expenses required to measure and implement the campaign in the first place?

As a rule of thumb, **I recommend a *minimum* of doubling your return on.** While looking for higher return is a great place to aim, you want to at least double your return to constitute the expense in the first place. Anything lower puts you at risk for losing your money toward ineffective marketing, and anything greater means that you are on pace for a truly successful campaign. I'd also recommend keeping a close eye on your returns and the techniques used to achieve them; this way you can refine and enhance your return with even more robust margins in the weeks and months to come, capitalizing on the successes you've already established.

If in fact you do achieve a low return on an investment, this doesn't mean that you need to scrap the campaign altogether. For example, what's the best course of action if you achieve a return of $750 USD on a $500 USD investment in a local magazine advertisement? In this situation, you can keep a close eye on this and either consider canceling your renewal or renew but keep a very close eye on the success of the campaign. You may decide in this particular case, the margins are sufficient, but that if improvement is not achieved within a certain amount of time, it's time to pivot and try another avenue altogether.

NEW CLIENT SOURCES

Something else that's extremely important to be mindful of is tracking your new client sources. The most common New Client Referral sources are as follows**: Search Engines, Website, Social Media, Community Based Print Advertising, Existing Clientele** (word of mouth) and **Community Events.** = Tracking your new client sources is an imperative step to success.

While this may seem like a lot of elements to account for, remember that each insight gained allows you to enhance your future marketing efforts. While perusing the data at first may seem

overwhelming or even unnecessary, **it is this data that is key to driving your most successful marketing efforts yet.**

TRACKING COUPONS

Coupons are a time tested and effective way to measure the overall effectiveness of your existing marketing campaigns. For example, if you're advertising in a local magazine, try adding a promotion for a "Free Nail Trim" directly onto the ad. Then, tally how many people come in with the coupon to start to boil down the figures on the success of the campaign. On each coupon, you'll want to specify the source by creating a **Coupon Code** that should be specified with a phrase. You may also wish to hand out promotional coupons at events sponsored or participated in by your veterinary practice, so you can see which events are worthwhile and bring in new clientele directly to your veterinary practice.

Some potential strategies for creating coupons include offering free services like grooming or nail trims, offering a free gift with a paid service. There is room to experiment with which promotions attract clients and are in high-demand, and by tuning into this feedback you'll stand the most to gain overall.

Remember, it's important to add a tracking code for each event and specific campaign so that you can measure the success of the campaign.

One of the most important takeaways, is learning how to move away from the "feeling" of success and toward the actual "execution" of success. For example, an event can feel like a true success after some positive interactions and feedback from attendees. But you can only know if the event is creating substantial ROI (Return On Investment) by implementing tools that measure your success in more tangible terms. Data is most certainly your friend when it comes to the world of digital marketing! In fact, the more data you use to implement your next marketing moves, the more you'll be moving toward the science of profitability.

TRACKING CLIENT RETENTION

It's also imperative to track your client retention, even while implementing the aforementioned marketing campaigns. Attracting clients is extremely important, but are they still visiting your veterinary practice 12 months later? To track client retention effectively, try pulling a report of clients who came to visit 18-24 months ago. Have those clients come back in for a repeat visit since then?

For example, if 18-24 months ago, you received 150 new clients total, but only 75 have come back in to visit your veterinary practice for repeat visits, this means that you have a retention rate of 50%.

If you want to improve business for your veterinary practice over the long-haul, set a goal of achieving client retention that's 5-10% higher than where you're at right now. Tracking client retention in this way will help you to determine which marketing efforts work better at attracting long term clients versus short term clients. While you do want to bring new clients through your front door, attracting clients that stay with you over a long period of time will yield far higher returns than clients that visit once and do not come back. If in fact you spent a substantial amount of marketing dollars to bring in that one-time client, you could be looking at low-margin profit, or even a loss.

FINDING THE RIGHT APPROACH FOR YOUR VETERINARY PRACTICE

While there are proven techniques that help to transition digital marketing away from a shot in the dark and instead toward more of a science, these techniques and your approach toward them will require examination and levels of refined implementation over time. A strategy that works effectively with a print magazine one year, could decline the next, especially if the circulation of the magazine decreases or more people begin to transition to reading a different magazine altogether.

The more you begin to clue into the world of digital marketing, successful approaches and the necessary adjustments needed, the easier it becomes to capitalize on successes and shed old ways of doing business that are no longer effective.

When you begin to implement the right combination of marketing techniques, accompanied with effective ways of measuring them, well, that's when you really start to get your veterinary practice purring the way it should.

Let's do this! Our last event is up next. I'm so proud of you.

About the Author: Eric Garcia is an IT expert. Digital marketer. Industry thought leader. When it comes to helping veterinary practices streamline their technology and attract and retain clients, Eric Garcia has a proven track record of educating the industry and producing results. Eric is an award-winning Global IT and Digital Strategist working *exclusively* within the veterinary field. In addition to a long list of satisfied clients, Garcia's work has been recognized throughout the industry. He speaks regularly at conferences all throughout the world. **Instagram:** @EricGarciaFL **Facebook:** facebook.com/EricGarciaFL **Twitter:** @EricGarciaFL

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Diane Deresienski

How to Address Common Medical Problems Encountered in Small Animal Practice

Diane Deresienski, VMD, DABVP (Canine/Feline Practice) Emeritus
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Lecture Outline:

- Broken Toe Nail
- "Happy Tail"
- Aural Hematoma hematoma auricular
- Boarding/Stress Diarrhea
- Anal Gland Abscess
- Allergic Conjunctivitis
- Hair Mats motas de pelo on Fat Cats
- Carnassial Tooth Root Abscess Absceso de la raíz del diente ca

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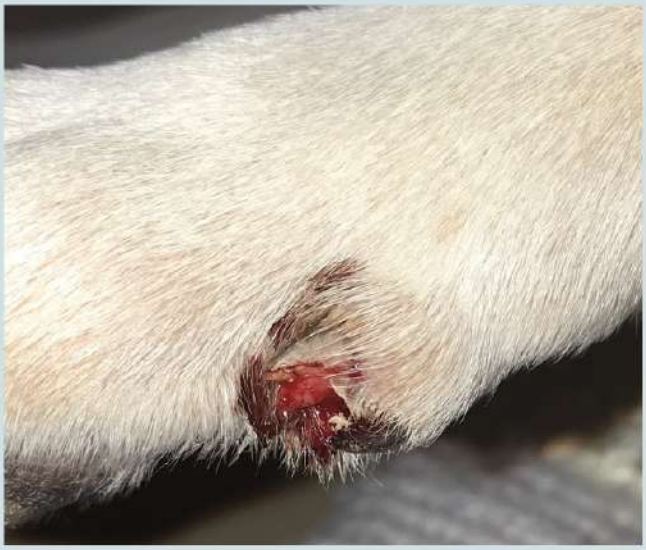
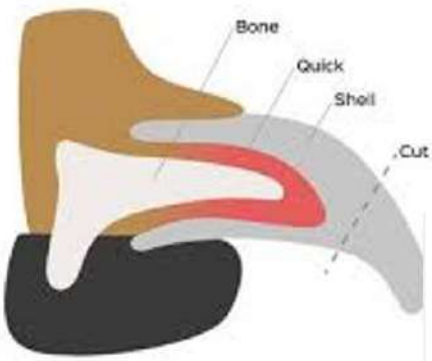
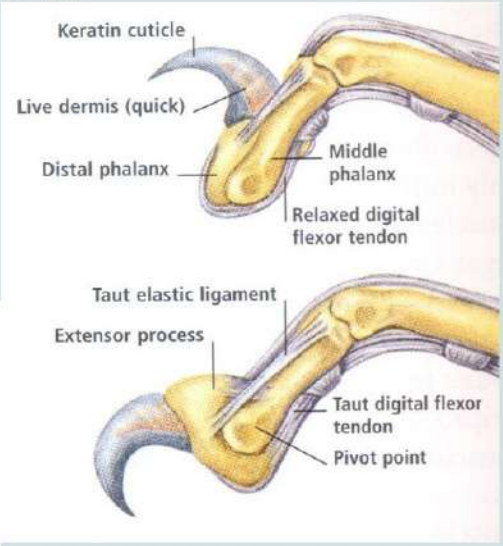
Broken Toenail



Nail Anatomy Review



1. light tissue is the curved bottom part of the nail
2. mottled light and dark tissue is the top part of the nail
3. gray to pink oval starting to appear at the top of the cut surface -- STOP CUTTING



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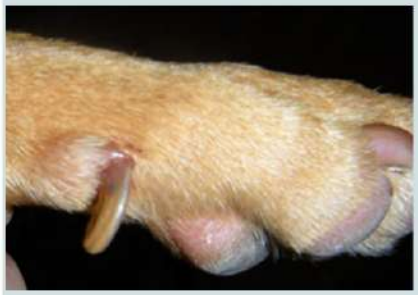
Presenting Complaints:

- Drops of blood around the home
- Excessive paw licking and biting
- Crying, yelping or whining
- Jagged appearance of claw
- Bloody paw
- Limping
- Pain when affected paw is touched
- Swollen paw
- Difficulty walking

Treatment Depends on Where the Break is:



Treatment

- Pain control
- Sedation
- Remove keratinized shell of nail if indicated
- Clean nail bed and exposed quick gently with dilute betadine/chlorhexidine
- Hemostasis-Yunnan Baiyao/styptic powder

polvo astringente

- Apply triple antibiotic
- Apply Telfa aposito telfa pad or non-stick bandage material
- Wrap with a padded bandage up to tarsus or carpus
- Change bandage frequently until the nail shell has grown out enough to be protective of the quick
- E. Collar

Differential Diagnoses:

- Multiple nails affected:
  - Lupoid Onychodystrophy
  - Vasculitis
  - Dermatophytosis/yeast infection
  - Food allergy
  - Poor diet
  - Hypothyroidism
- Single nail affected
  - Nail bed tumor tumor del lecho ungueal

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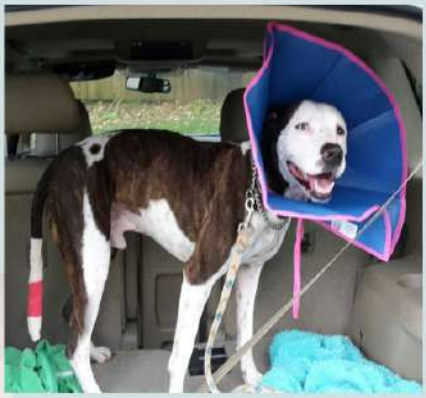
What is Happy Tail?

"Happy Tail"



Happy Tail

- Effects “happy” dogs that wag their tail vigorously
- Large, thin, long-tailed dogs (Great Danes predisposed)
- Often difficult to treat

Treatment Goals:

- Stop trauma to tail tip with bandaging and tail stabilization
- Treat infection
- Sedation/pain medication
- Avoid necessity of tail amputation

Tail Immobilization Techniques

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Bandaging Options

Unfortunately, "Happy Tail" often results in Tail Amputation

"It's hard to stop a happy dog from wagging it's tail!"

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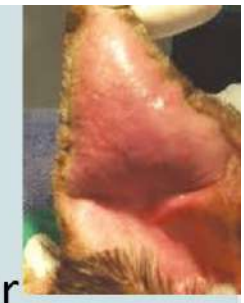
Aural Hematoma



- Diagnosis- ear pinna pabellon auricular feels like a water balloon
- Concomitant otitis externa often the cause of self trauma to the ear pinna
- DDX: clotting disorders, tumor, increased capillary fragility in Cushing's disease
- Treatment options- several

Cauliflower Ear Possible if Left Untreated

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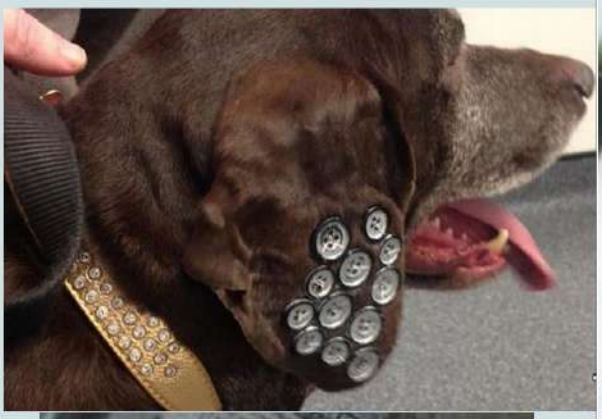
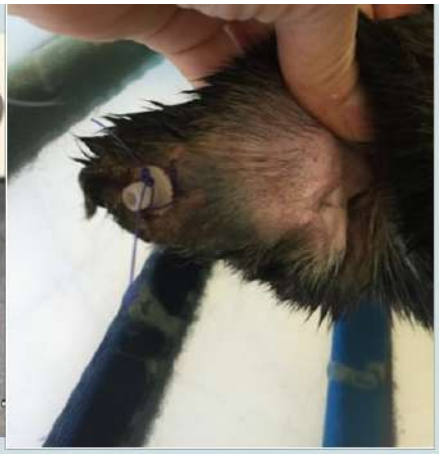
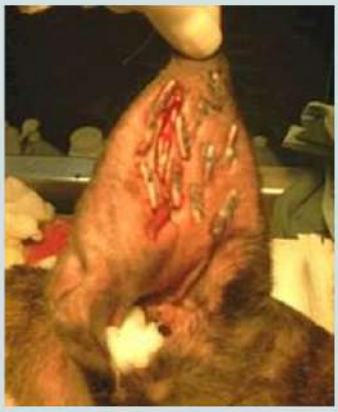
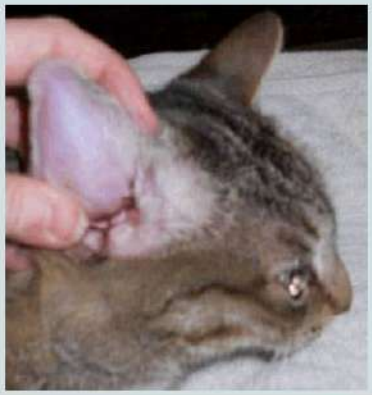
Treatment Options

- Needle aspiration and bandaging -25% success
- Tube (teat cannula canula de tetina) drainage systems -50% success
- Surgery- Incise and drain the fluid, followed by placing "quilting" sutures sutura de colchonero to prevent reoccurrence -95% success
- Bandaging after surgery to decrease swelling, discharge, and trauma.
- Treat otitis externa- ear cytology/- culture then appropriate medications









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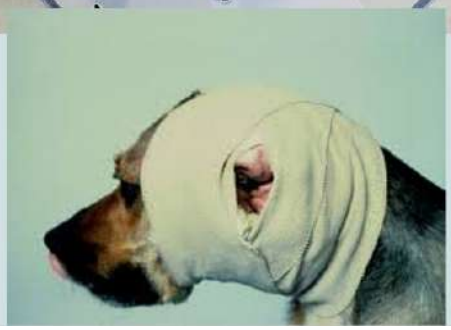
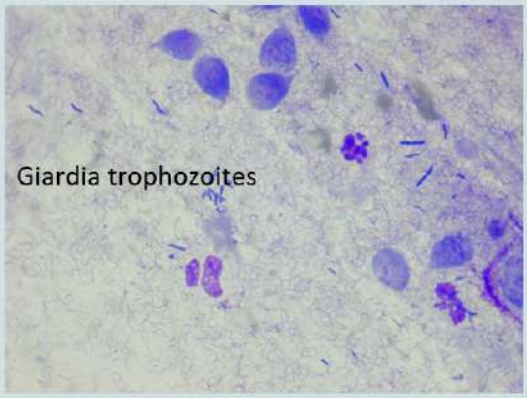
Prevention of the "Crime Scene" Look in your Client's Home!



Acute Uncomplicated Diarrhea

- Causes:
  - Stress
  - Boarding
  - Travel
  - Extreme exercise
- Diagnostics
  - Physical Exam
  - CBC/Chemistry panel (R/O HGE)
  - Fecal float and cytology in house
  - Frank blood in stool



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Treatment

- Look at your patient:
  - Bouncy or lethargic?
  - Urgency, tenesmus?
  - Eating or inappetant?
  - Recent stress, boarding, grooming?
- Controversy:
  - Probiotics
  - Metronidazole
  - Tylosin
  - None-self limiting

Anal Gland Infection/Impaction/Abscess

- Presenting complaint:
  - Licking under tail
  - Scooting
  - Painful when defecating or sitting
  - Blood tinged discharge found

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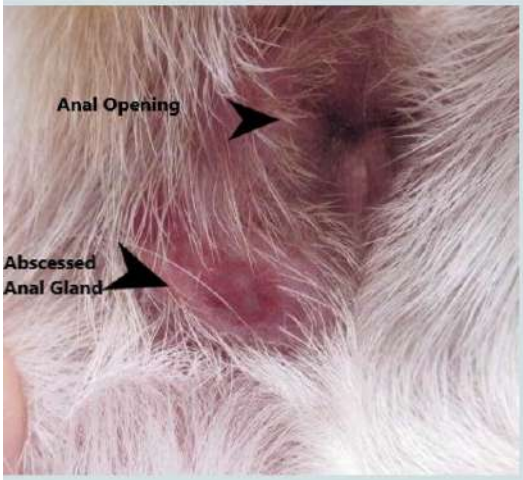
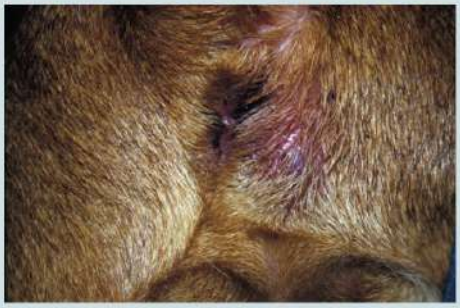
OUCH!





Yes, It Happens to Cats as Well!

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Examination

- Gentle initial palpation of the affected area
- Very painful- need sedation (IV Dexmedetomidine/Butorphenol or Valium/Ketamine)
- After sedation:
  - Clip and clean the area to assess
  - Rectal palpation of both anal glands (AG) and express both if possible
  - Aerobic culture and sensitivity
  - Determine if infected, impacted and/or ruptured

Treatment

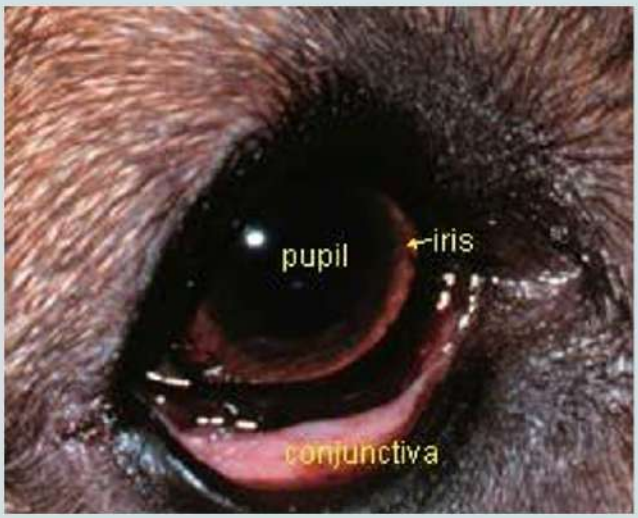
- Express material in the gland if not impacted
- Culture expressed material
- Flush AG with dilute chlorhexidine or povidone iodine
  - Lubricated olive tipped curved metal catheter or IV catheter
  - Flush until solution is clear
  - If AG is ruptured flush both the duct and ruptured area
- Infuse an antibiotic/anti-inflammatory into gland
- Send home with antibiotics, NSAID and pain medication
- E. Collar

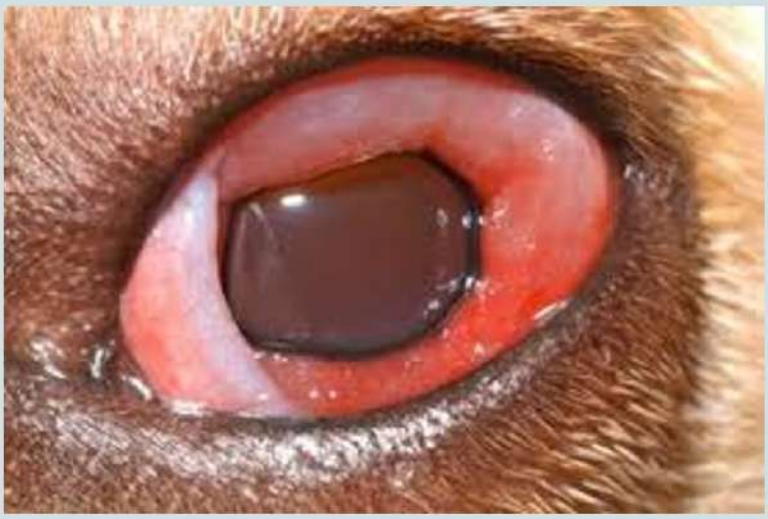
•

Prevention

- Express AG monthly
- Canned Pumpkin 1 Tbsp(15ml) per 30 lbs once or twice daily
- Vetri-science "Express Ease" added to diet
- Weight loss
- If chronic infection/impaction-recommend anal sacculectomy-prevents pain and possible anal gland adenocarcinoma in future

Allergic Conjunctivitis





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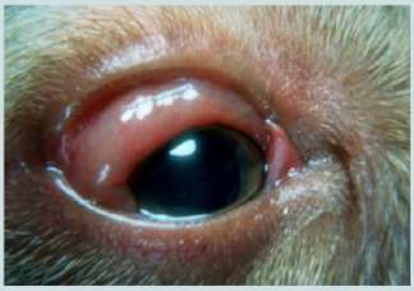
Clinical Signs

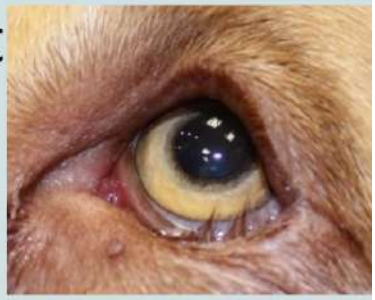
- Both or one eye affected
- Seasonal
- Concurrent atopic dermatitis
- Local hypersensitivity reactions due to insects and allergen particles -can cause inflammation in only one eye.

Exam Findings



- Hyperemia of conjunctival vessels
- Conjunctival edema (ie, chemosis), swelling, and thickening
- Ocular discharge, which may be serous, mucoid, or purulent
- Hypertrophy of lymphoid follicles, particularly on the inner aspect of the third eyelid
- Conjunctival ulceration and subconjunctival hemorrhage
- Minimal ocular pain, possible discomfort expressed as mild blepharospasm

Rule Out Before Treatment



- Entropion
- Corneal Ulcer (Florescene Stain)
- Ectropion
- KCS (Dry eye) (Schirmer Tear Test) queratoconjuntivitis seca
- Cherry Eye
- Eyelash disorders (eg, distichiasis, trichiasis, ectopic cilia)
- Rubbing of the nasal folds against the conjunctiva

Treatment

- Topical glucocorticoids +/- antibiotics
  - Warn owner to watch for squinting, eg. Corneal ulcer
- Topical or oral NSAIDS
- Oral antibiotics
- E. collar
- Avoidance of the inciting allergen
- Possible hyposensitization

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Hair Mats on Chubby Cats

Reasons for Decreased Grooming

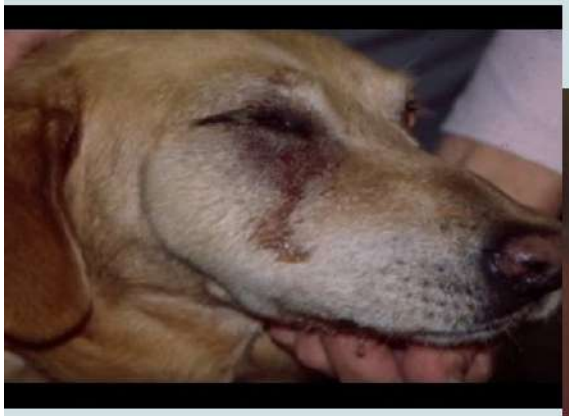
- Obesity- cannot reach back to groom
  - Cannot clean perineum- Cystitis
  - Flaky seborrheic skin
- Arthritis-too painful to do cat yoga

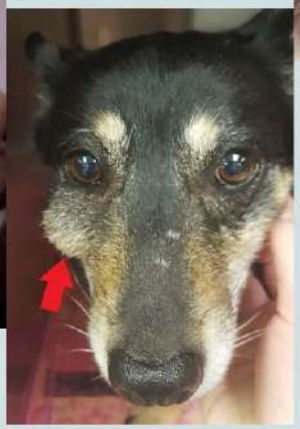
•

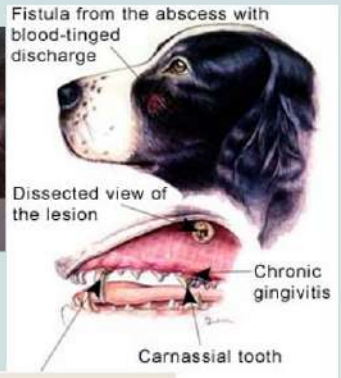
Treatment

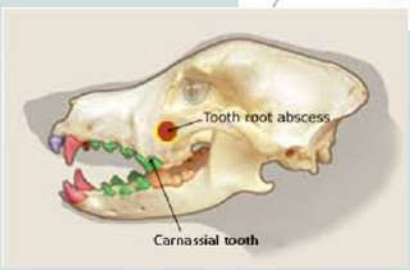
- Treat the matting
  - Sedation
  - Careful grooming-owners often cut skin
- Treat the skin
  - Skin is irritated, infected, seborrheic
- Treat the underlying condition
  - Obesity-change diet and management of feeding
  - Arthritis- Gabapentin, Adequan, Meloxican,
  - Solensia-Monoclonal Antibody monthly injection $$

Carnassial (Upper 4th premolar) Tooth Root Abscess









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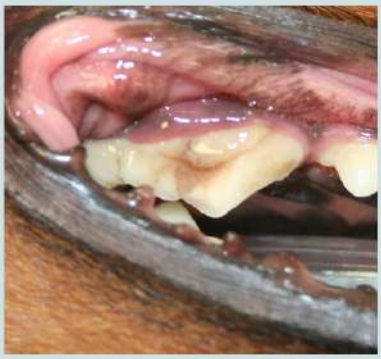
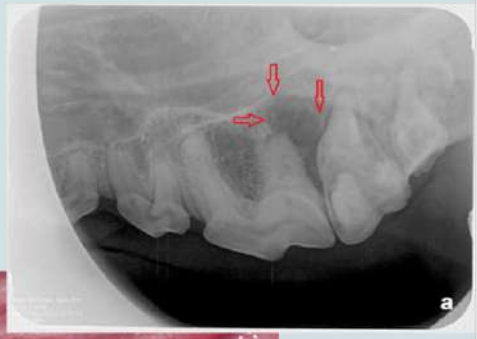
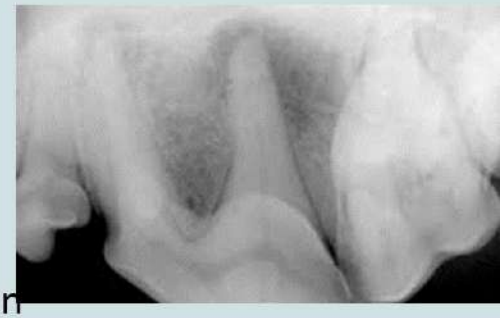
Cause of Carnassial Tooth Abscess





Treatment



- Treat infection and inflammation:
  - Antibiotic: Clindamycin or Clavamox
  - NSAIDs
  - Pain medication
- Dentistry: COHAT, Dental Radiographs, extraction
  - Maxillary nerve block-Bupivacaine
  - Intraoperative radiographs before and after extraction
  - Curettage and flush tooth root abscess and facial abscess with dilute Chlorhexidine
  - Continue antibiotic, NSAID and pain medication for 7-10 days

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Prevention

- Oral home care-Oravet chews, Veggie Dent chews, Daily brushing, Dental diets such as Purina DH or Hills T/D diet
- Only feed chews that you can bend slightly (no antlers)
- Yearly dental prophylaxis if indicated

The End…

Any Questions?

IMPORTANT CONSIDERATIONS IN SMALL ANIMAL EUTHANASIA

Diane Deresienski VMD, DABVP (Canine/Feline Practice)
Consultant: Universidad San Francisco de Quito
College of Veterinary Medicine
Quito, Ecuador
Adjunct: Professor: NC State University
College of Veterinary Medicine
North Carolina, USA

Euthanasia

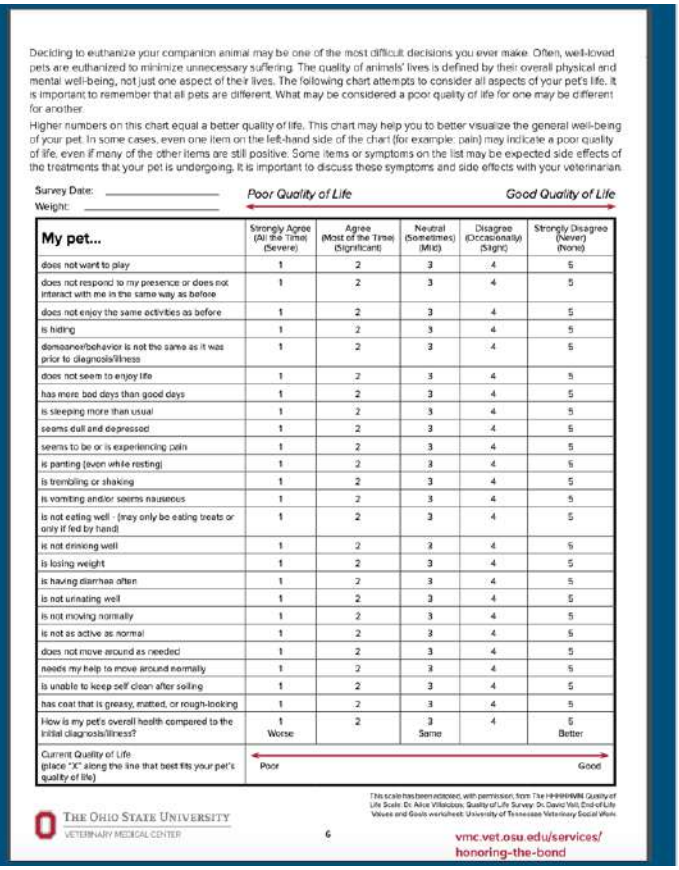
Derived from the Greek language
"Eu" meaning good and "thanatos" meaning death

How can we help pet owners make the decision?

- Making the decision is sometimes the hardest part
- Truthful discussion with the owners is important
- Let the owners know if the animal is in pain and if the pain can be treated
- Describe what the animal is going through and what the future holds
- Objective surveys can be helpful:
  - https://www.lapoflove.com/how-will-i-know-it-is-time/lap-of-love-quality-of-life-scale.pdf
  - https://vmc.vet.osu.edu/sites/default/files/documents/how-will-i-know_rev_mar2024ms_0.pdf

Excellent Objective Chart:

- Helpful for owners to realize what the pet is going through
- Helps them recognize progression of disease if they repeat over time
- https://vmc.vet.osu.edu/sites/default/files/documents/how-will-i-know_rev_mar2024ms_0.pdf



Deciding to euthanize your companion animal may be one of the most difficult decisions you ever make. Often, well-loved pets are euthanized to minimize unnecessary suffering. The quality of animals' lives is defined by their overall physical and mental well-being, not just one aspect of their lives. The following chart attempts to consider all aspects of your pet's life. It is important to remember that all pets are different. What may be considered a poor quality of life for one may be different for another.

Higher numbers on this chart equal a better quality of life. This chart may help you to better visualize the general well-being of your pet. In some cases, even one item on the left-hand side of the chart (for example: pain) may indicate a poor quality of life, even if many of the other items are still positive. Some items or symptoms on the list may be expected side effects of the treatments that your pet is undergoing. It is important to discuss these symptoms and side effects with your veterinarian.

Survey Date: _____
Weight: _____

Poor Quality of Life ← → *Good Quality of Life*

My pet...	Strongly Agree (All the Time) (Severe)	Agree (Most of the Time) (Significant)	Neutral (Sometimes) (Mild)	Disagree (Occasionally) (Slight)	Strongly Disagree (Never) (None)
does not want to play	1	2	3	4	5
does not respond to my presence or does not interact with me in the same way as before	1	2	3	4	5
does not enjoy the same activities as before	1	2	3	4	5
is hiding	1	2	3	4	5
demeanor/behavior is not the same as it was prior to diagnosis/illness	1	2	3	4	5
does not seem to enjoy life	1	2	3	4	5
has more bad days than good days	1	2	3	4	5
is sleeping more than usual	1	2	3	4	5
seems dull and depressed	1	2	3	4	5
seems to be or is experiencing pain	1	2	3	4	5
is panting (even while resting)	1	2	3	4	5
is trembling or shaking	1	2	3	4	5
is vomiting and/or seems nauseous	1	2	3	4	5
is not eating well - (may only be eating treats or only if fed by hand)	1	2	3	4	5
is not drinking well	1	2	3	4	5
is losing weight	1	2	3	4	5
is having diarrhea often	1	2	3	4	5
is not urinating well	1	2	3	4	5
is not moving normally	1	2	3	4	5
is not as active as normal	1	2	3	4	5
does not move around as needed	1	2	3	4	5
needs my help to move around normally	1	2	3	4	5
is unable to keep self clean after soiling	1	2	3	4	5
has coat that is greasy, matted, or rough-looking	1	2	3	4	5
How is my pet's overall health compared to the initial diagnosis/illness?	1 Worse	2	3 Same	4	5 Better
Current Quality of Life (place "X" along the line that best fits your pet's quality of life)	Poor				Good

This scale has been adapted, with permission, from The HHHHMM Quality of Life Scale. Dr. Alice Villalobos, Quality of Life Survey. Dr. David Vail, End-of-Life Values and Goals worksheet. University of Tennessee Veterinary Social Work.

The Ohio State University Veterinary Medical Center

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vmc.vet.osu.edu/services/honoring-the-bond

Prior to the Euthanasia

- Be sure to speak with the client prior to the procedure to give them information about how it will work and discuss the process
- Make the appointment at least 40 minutes so it doesn't feel rushed
- Send pre-appointment sedation pills home with the owner or have them come in to the hospital pick them up
- Discuss burial or cremation options and cost
- Assure the owner that they are doing the most caring thing the can do for the pet to end suffering
- Have client pay the bill ahead of time so they can leave right after the procedure

Sedation prior to euthanasia

Step one: Owner to give relaxing medication at home if possible-

- Goal is to relax the pet but not completely sedate them
- If the pet has been on pain medication, the owner can be asked to give this prior to the appointment
- Cats: Gabapentin 100-200mg/cat depending on the cat's weight and personality-given the night before and 3 hours before the appointment
- Dogs: Trazodone 5-10 mg/kg orally and Gabapentin 20-30mg/kg orally 3 hours before vet appointment depending on health of the pet

Steps for a Good Death:

- sedation is essential to ensure a smooth, peaceful passing
- include discussion about sedation in your initial contact with the client
- sedative choice depends on many factors: species, breed, size, health status, personality, anxiety level
- can mix multiple drugs in one syringe for sedation
- use a fresh, sharp needle for injection- smaller vs larger needle depending on sensitivity of patient vs importance of speed of injection
- subcutaneous is preferable route but can use intramuscular

Continued:

•explain to the client how you will give the injection and have them give a special treat/pet/scratch as a distraction

•explain how long it will take to take effect – from noticeable changes to full effect

•advise the owners to remove food/water a few minutes after the injection as the animal won't be able to swallow as well

•discuss any possible side effects: -twitching -heavier breathing -nausea (avoid these drugs if possible)

•after the injection is given stroke and talk to the pet along with the owners

•once the patient is well sedated, you may choose to move small pets to a more comfortable location such as the couch, bed, or owner's lap

Sedation prior to euthanasia

Step 2: Sedation in the veterinary office

- Veterinarian to assess the level of sedation
- If more sedation is needed, an injectable sedative can be given at this time
- Options for cats are Butorphanol 0.2-0.4mg/kg and/or 3.0-5.0 mg/kg Alfaxalone SQ
- Options for dogs are Acepromazine 0.03mg/kg and Buprenorphine 0.02 mg/kg SQ
- After sedation, place an IV Catheter. Ask owner if it is OK for you to bring the pet to the catheter station for IV placement, but if they prefer, you can always place it in the room with them

Last injection:

- Euthanasia solution can be thick and difficult to inject so mix it with 1-3 mls of water to ease the injection through the IV catheter
- Flush the IV catheter first with saline
- Talk to the owners in a calming voice and let them know that if they are ready, you will start the final injection that will just let them drift off in peace.
- Always use your stethoscope and listen to the heart until it stops
- Let the owners know that the pet is at peace and there is no longer any pain or suffering

Best euthanasia rooms: quiet, peaceful, like home:

Plants, quiet music, scented candles, soft blankets, pillows are helpful

At Home Euthanasias:

PROS:

- Clients are very grateful for this service
- Very emotionally difficult for clients to bring their pet into hospital for euthanasia
- Veterinarian is not distracted by other clients and appointments

CONS:

- May take longer due to travel time
- Low lighting at home can make it difficult to put in an IV catheter
- Need to be prepared with all the equipment you need to be successful

Medical Kit for in home euthanasias:

Hair clippers

IV Catheters of different sizes

Bandage material and tape

Alcohol/Betadine (Careful It staines)

Bright light or headlamp

Blankets (2)

Urine pad

Gurney/stretcher to carry large dogs

Dog/Cat treats

Kleenex for clients

Ensure that your vehicle will fit a large dog if bring body back to vet hospital

Sedatives ready in syringe

IV Euthanasia medication (Bring extra!)

Provide a memento for the client:

Many cremation companies provide these options

Veterinarians are blessed to provide a Good Death

- We can stop suffering for our patients which is our main goal
- It can be hard for us as well if we have a close relationship with the animal or the clients
- It is an emotionally charged service that can cause considerable stress
- Have an assistant/vet technician with you to help with IV catheter placement, etc
- You never have to perform a euthanasia if you don't feel it is necessary or in the animal's best interest

Preguntas?

Single Rooted (Simple) Dental Extractions in Canine and Feline Patients

Diane Deresienski VMD, DABVP (Canine/Feline Practice)
Consultant: Universidad San Francisco de Quito
College of Veterinary Medicine
Quito, Ecuador
Adjunct Professor: NC State University
College of Veterinary Medicine
North Carolina, USA

What Is The difference between A Simple Extraction And A Surgical Extraction?

- **Simple extractions** involve the removal of single rooted teeth but not all single rooted teeth can be extracted with a simple extraction technique. Simple extractions in some cases are not always as simple as their name implies. Fractures during extraction may require surgical methods to complete the procedure.
- **Surgical extractions** involve making periodontal flaps and the removal of bone to expose tooth roots and sectioning of the tooth.

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Anesthesia and Safety Measures

- General anesthesia is required to perform simple and surgical extractions and dental cleanings
- The endotracheal tube must have an inflated cuff to ensure no water or debris can enter the lungs
- A patient warming device is necessary; many dental procedures can take 1-4 hours
- Intravenous fluids to maintain hydration and blood pressure are necessary
- Access to IV or SQ drugs to increase blood pressure or treat arrhythmias if needed
- A trained assistant or veterinary technician are necessary to monitor the patient for the whole procedure

Safety Measures for the Doctors and ~~A~~ssistants

- Wear personal protection equipment
  - Bouffant cap/Surgery Cap
  - Face mask
  - Gloves
  - Goggles or Face Shield

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Ergonomics Matter!

Dental instruments used for Simple Extractions:

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Dental Tray Set Up For Extractions

Which teeth can be extracted as simple ~~ex~~tractions?

- Incisors
- Deciduous canine teeth
- 1st Upper premolars in cats
- 1st Upper premolars in dogs
- 1st lower premolars in dogs
- What about Canine teeth- they are single rooted teeth!

Simple Extraction Technique involves the Following:

1. Disinfection of the oral cavity with 0.0125% chlorhexidine rinse

2. Breakdown of the epithelial attachment with a scalpel or luxator

3. Severance of the periodontal ligament with a luxator or periotome

4. Establishment of purchase with a luxator or elevator between the

bone and the tooth

5. Slow and sustained pressure with a luxator or elevator to fatigue the periodontal ligament. Ten to fifteen seconds is generally recommended

6. Use extraction forceps to provide slight twisting pressure combined with coronal traction to complete the extraction

Tips for Successful Simple Extraction:

- Find an elevator that fits the contour of the tooth well
- You are trying to get the elevator seated in between the bone of the alveolus and the tooth
- A twisting or rotational force is applied to the tooth such that a small amount of movement is noted
- Periosteal fibers have to be broken down to allow a tooth to be extracted
- Force must be applied a constant rate to be most effective. 20-30 seconds of continuous force is recommended-Sing “Happy Birthday” Twice!

Demonstration of How to use the Dental Elevavator in a Simple Extraction:

https://www.youtube.com/watch?v=hSY3oMUtLF4

After the Tooth is Extracted:

- Currette the sulcus if there was a visible abscess
- Flush sulcus with a very dilute chlorhexidine solution
- Apply one absorbable monofilament simple interrupted suture to close the opening and hold in the blood clot that forms-no need to remove sutures in future

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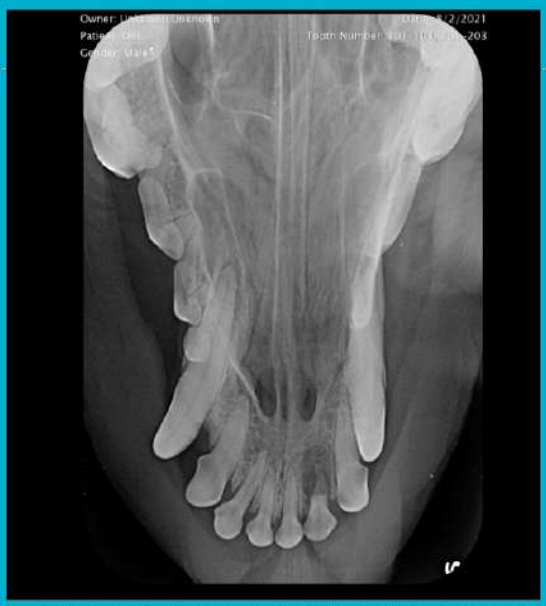
Significant Bone Loss:

Abcessed Incisor:



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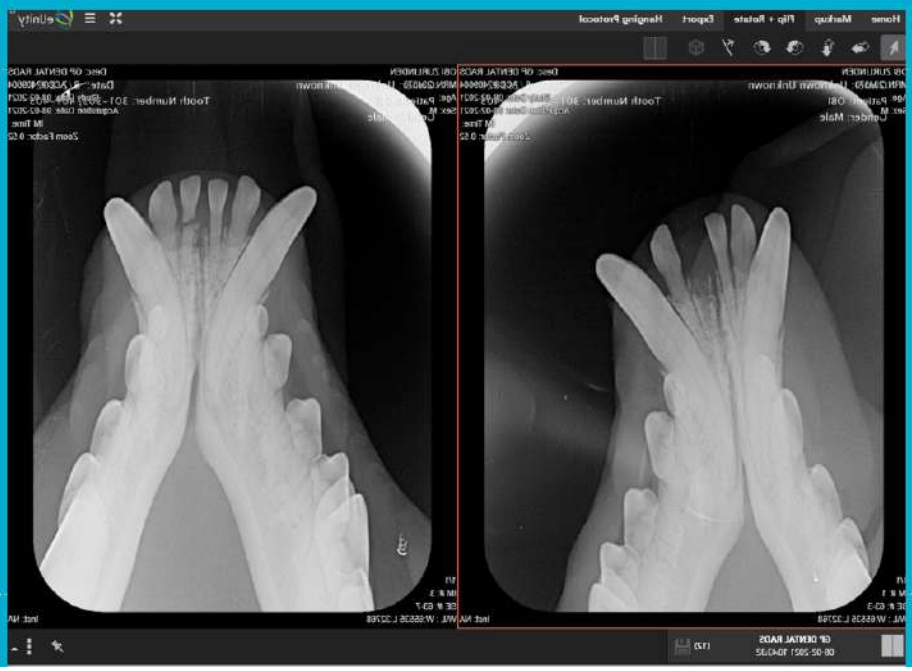
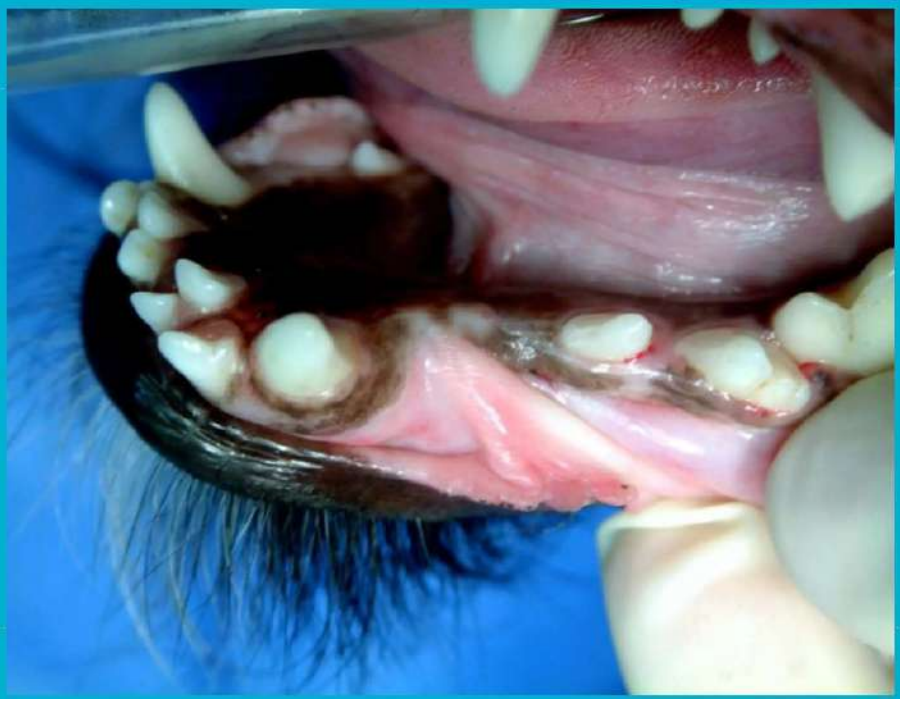
Fractured Incisor:



Malocclusions of Incisors:



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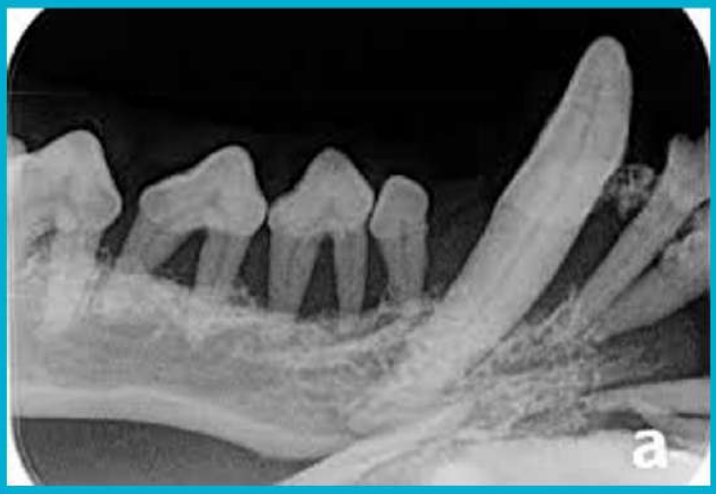
Significant Periodontal Disease and Bone Loss



Hay Preguntas?

Surgical Extractions in Canine and Feline Patients

Diane Deresienski VMD, DABVP (Canine/Feline Practice)
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What Is The difference between A Simple Extraction And A Surgical Extraction?

- Surgical extractions involve periodontal flaps and the removal of bone to expose tooth roots. Simple extractions do not require periodontal flaps or removal of bone, however if a tooth root fractures occurs during a simple extraction, it may require surgical methods to complete the procedure.
- It is necessary to section a two or three rooted tooth to form two or three single roots respectively in a surgical extraction.

Anesthesia and Safety Measures

- General anesthesia is required to perform simple and surgical extractions and dental cleanings
- The endotracheal tube must have an inflated cuff to ensure none of the water or particles from the extraction can be inhaled.
- A warming device is necessary; many dental procedures can take 1-4 hours
- Intravenous fluids to maintain hydration and blood pressure are necessary
- Access to IV or SQ drugs to increase blood pressure or treat arrhythmias if needed
- A trained assistant or technician are needed to monitor the patient

A Dental High Speed Drill Is Necessary

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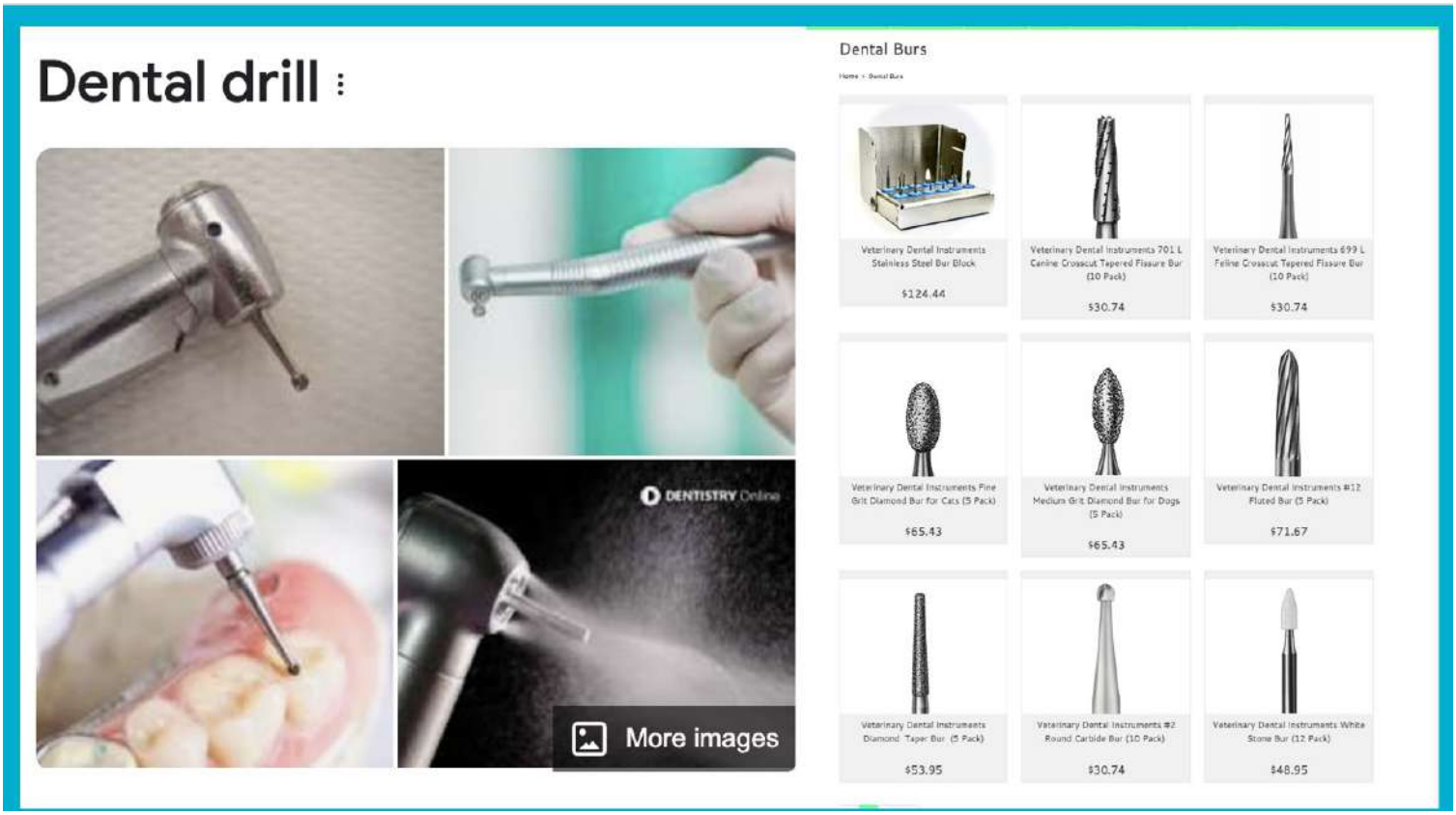

Surgical Extracions are Required for:

- A fractured, abscessed or painful 2 or 3 rooted teeth in cats and dogs
- All fractured or abcessed canine teeth in dogs or cats due to amount of bone structure around the tooth root
- Severe periodontal disease in dogs
- Stomatitis or tooth resorption in cats
- Teeth involve in Dentigerous Cysts

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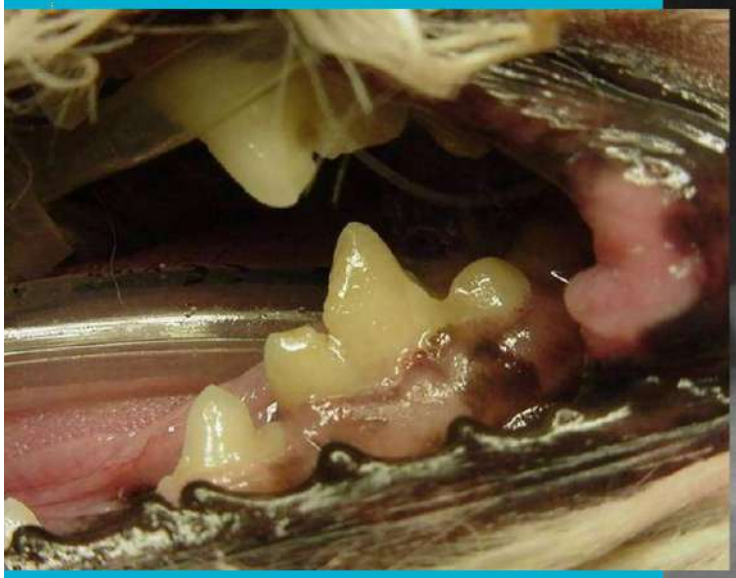
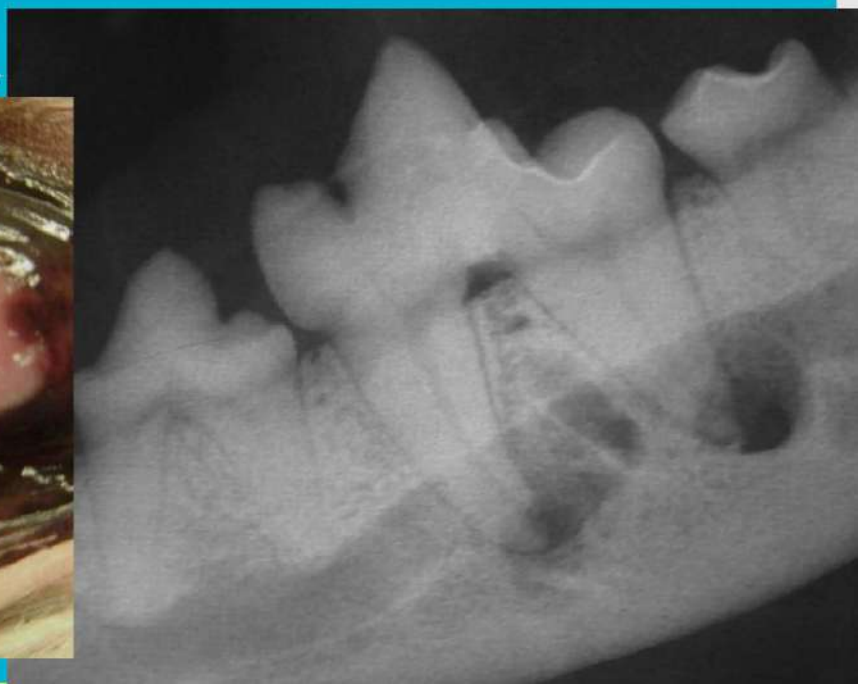
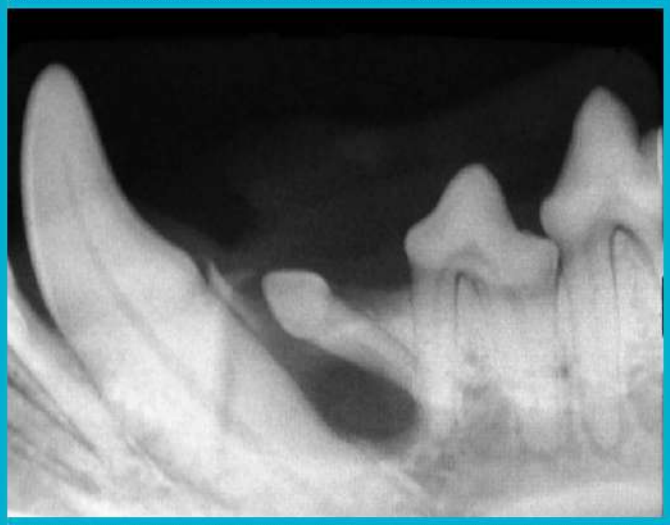
Dental Radiographs are Extremely Helpful:





Dentigerous Cysts



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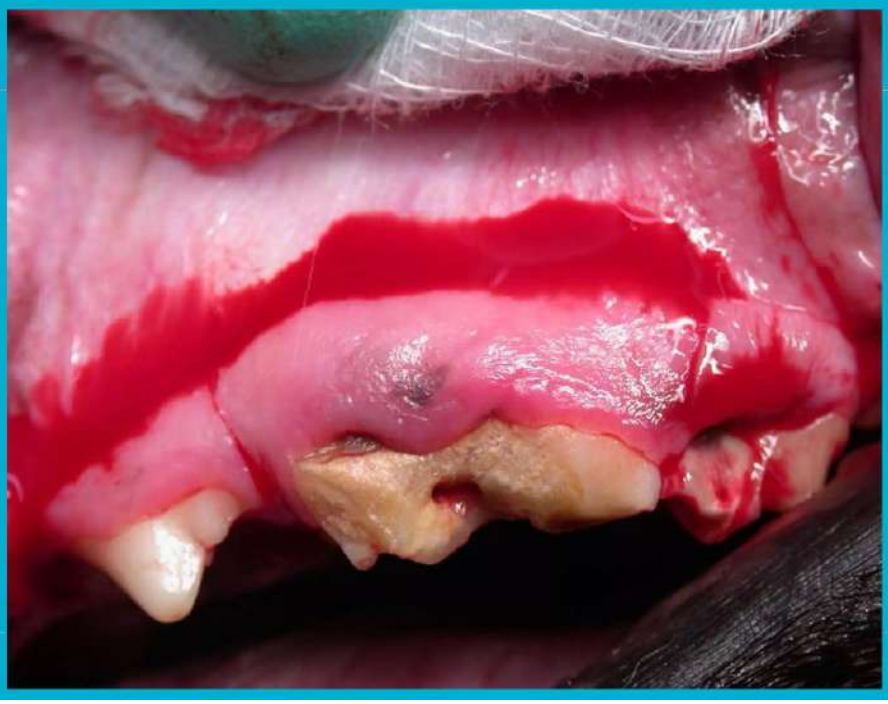
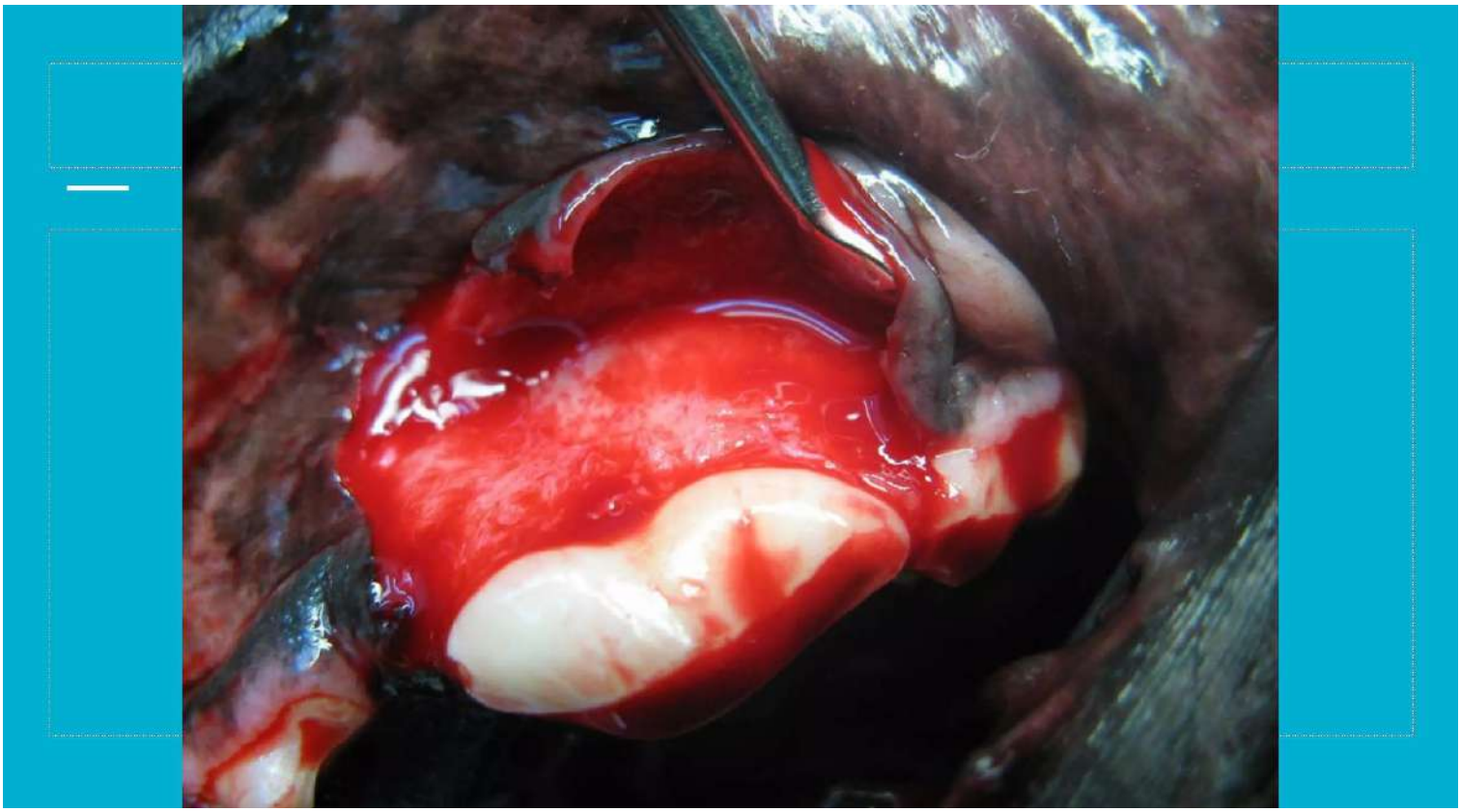
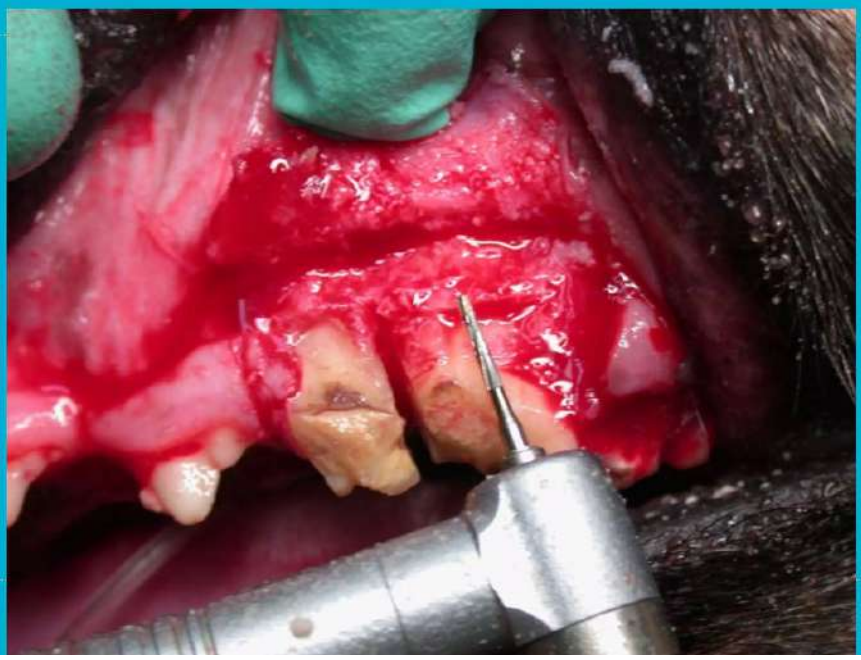
Gingival Flap Preparation for Canine Tooth Extraction

Gingival Flap Outline for Left Maxillary 4th Premolar





Dental Bur is Used to Section Between 2 Roots



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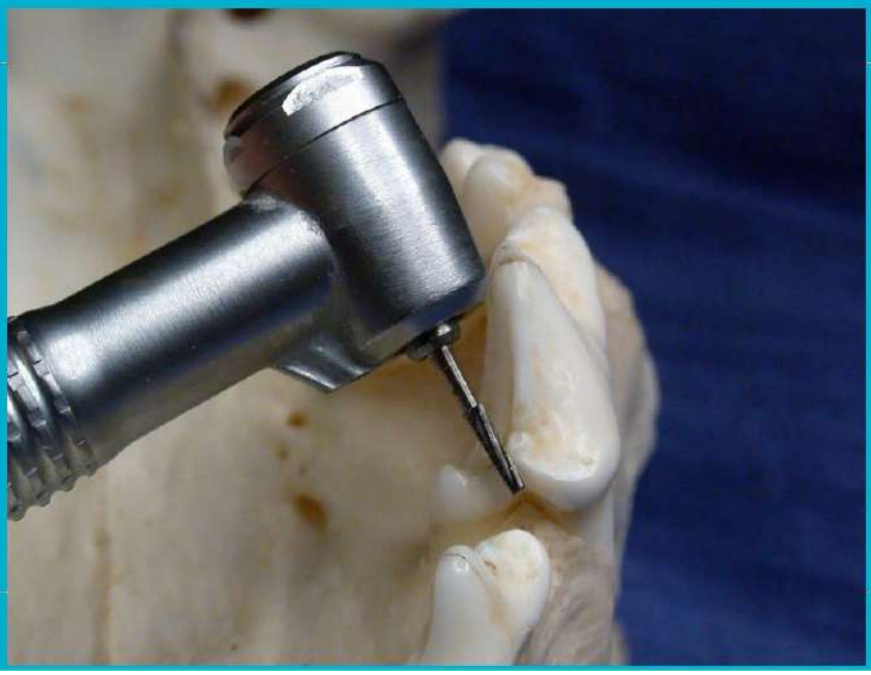
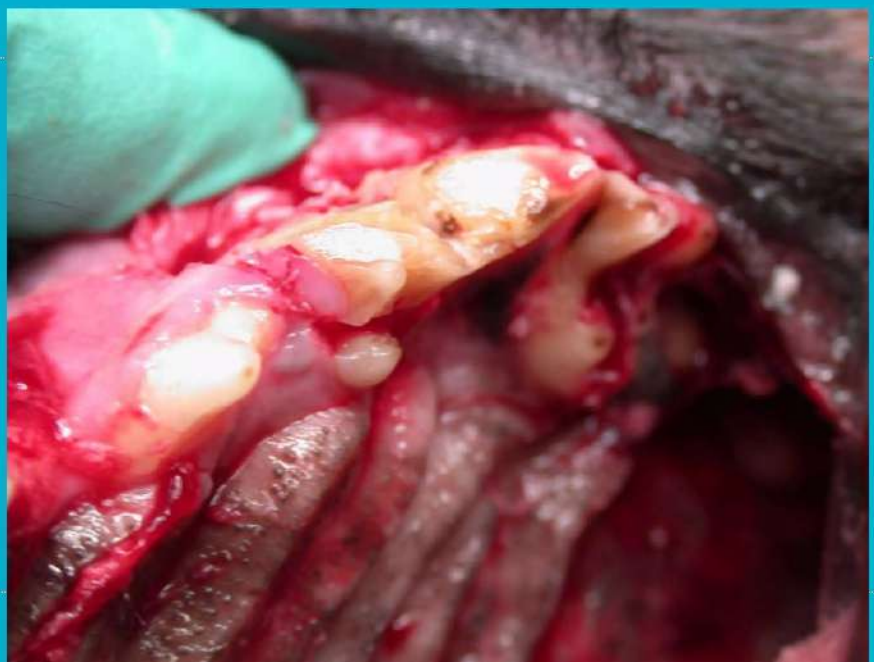
The Bur Placement for Sectioning the 3rd Root



Sectioned Palatal root of the Maxillary 4th Premolar



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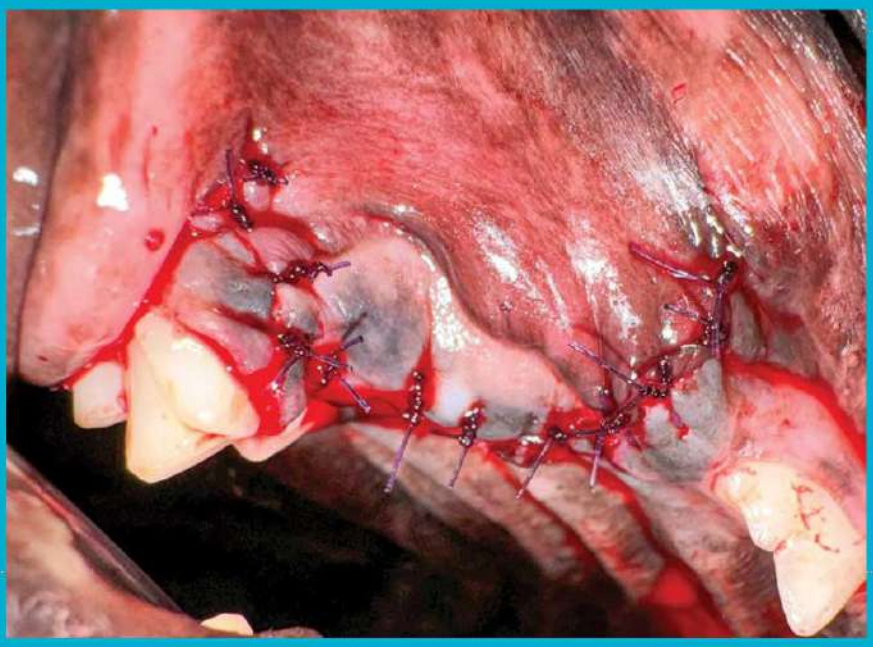
Maxillary 4th Premolar Surgical Extraction

Courtesy of Dr Brett Beckman

https://www.youtube.com/watch?v=xR7sCCAugeI

Sutured Gingival Flap Post-extraction of 4th Maxillary Premolar



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My Favorite Suture for Gingival Flaps

Maxillary Right Canine Tooth Surgical Extraction

Courtesy of Dr Brett Beckman

https://www.youtube.com/watch?v=vnNtlsb6rmg&rco=1

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Thank you for your attention!

VETERINARY COMMUNICATION AND DOCUMENTATION

Diane Deresienski VMD, DABVP (Canine/Feline Practice) Emeritus
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Good Communication Can Make or Break Your Practice

- Good communication is critical to professional success.
- Even in a profession focused on animals, the ability to communicate e
  is vital to client and staff relationships.
- How we communicate can be louder than what we communicate.
- Generational, gender, and cultural differences increase the need for thoughtful communication.
- Taking the time to work on communication skills can have great payback by decreasing stress and increasing success.

Listen

- Good listening leads to better responding
- Pay attention to what your client is saying
- Try not to process your response while a person is talking because this decreases what you actually hear
- Truly listening requires being grounded in a healthy respect for others and a willingness to consider other perspectives.

Keep it Positive

- Mention the good things that are happening, especially if you have to talk about a difficult subject.
- It is generally easier to follow positive directives so prescribe what a person is to do, rather than what they should not do.
- Offer sincere affirmations along with what may be difficult to hear. For example, before approaching a client on lack of compliance, make note of the ways she/he has showed care for a pet.

Use "I" Statements

- When we are frustrated or challenged it is easy to fall into patterns of blaming or denial,THIS IS NOT HELPFUL.
- Using statements starting with "I" rather than "you" can be less offensive and more accurately reflect our perception.
- For example, "I will be so happy to see how much weight Kitty can lose on the weight management diet" rather than "You have to feed her only this weight management diet and stop feeding her your own food!"

Monitor Your Own Mood

- Body language is loud and how we feel is easily communicated
- When we are irritated, frustrated, tired, or focused on a task it comes through in how we communicate
- Clients and staff may take it personally even though our mood has nothing to do with them
- Be intentional about how to communicate especially when it is not easy being your ideal self
- Take a deep breath, give yourself a positive thought, and allow yourself a calming moment when you need a mood adjustment
- Doing this can prevent miscommunications and hurt feelings.

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Veterinary Medical Records and the Importance of Documentation

- Complete medical records not only provide important information about your patients, but they also protect you against false claims of negligence.
- Without proper documentation in a patient's record a veterinarian cannot prove they provided proper care to that patient.
- If you didn't write it down, you didn't do it!!

Good Record Keeping is…

1. Required by state veterinary boards and practice acts in U.S.A.
2. Evidence to support your standard of care
3. Easy to read and follow
4. Helpful to resolve client disputes
5. Key to your defense in a malpractice claim or board complaint

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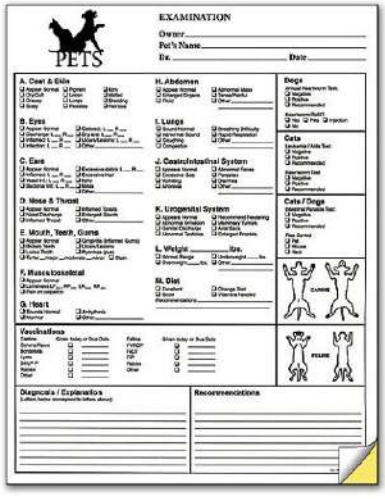
Before Appointments	Ask the client to verify all contact information and all people authorized to make medical decisions.
	Record clinical history and all current medications. Clearly note any patient medical alerts such as drug or vaccine reactions, as well as alerts regarding aggressive behavior and/or the need to muzzle.
	Include all approved (and declined) treatment plans.
	Include all signed consent forms, clearly stating the procedure or treatment being authorized. Work with your personal attorney to develop a consent form that fits your practice needs.

During Procedures and Appointments	Note all physical exam findings, even if the exam is brief.
	Include a detailed anesthetic and surgical report describing the endotracheal tube size, all drug names and doses, record of vital signs that were monitored, time of extubation, suture size and pattern, surgical findings and technique.



Diagnosis and Treatment	Document all client discussions including differential diagnoses, recommended diagnostics and treatment options.
	Document whether a referral was offered and declined/accepted.
	Clearly outline all treatments for in-hospital patients.
	Inform the client if a drug is extra-label and/or compounded.
	Clearly note if a client declines treatment against medical advice.
	Document client discussions regarding known adverse effects of drugs and vaccines. Issue a client drug handout, especially when prescribing NSAIDs.


Sample Discharge Instructions


HUMANE SOCIETY of Portage County
Feline Spay
Surgical After Care Instructions


Home Care Instructions

Documentation Errors to Avoid

- Illegible handwritten entries. This makes it difficult and confusing for another veterinarian or technician to follow your treatment plan, increasing the risk of medical errors.
- Including inappropriate entries in the medical record. Negative comments about the client or animal as well as offensive language should not be part of the medical record. Only enter information pertinent to the medical care of the patient into the medical record.
- Failing to document patient status and medications administered to boarding patients.
- Failing to keep a detailed anesthesia report, verifying that the patient was adequately monitored while under anesthesia and during post-operative recovery.
- Failing to write a detailed surgical report.
- Failing to provide discharge instructions in writing.
- Failing to confirm that consent forms have been signed by the client.


Improved Communication and Documentation takes time to master but it will benefit your practice and increase job satisfaction... It's worth the effort!
Any Questions?

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Douglas Mader

MS, DVM, DABVP

Douglas Mader, MS, DVM, DABVP (C/F, R/A), DECZM (Herpetology)

Tropical Veterinary Services, Big Pine Key, FL USA

The objective of this presentation is to present a very basic approach to reptilian anatomy. This will help the student/practitioner better interpret radiographs, perform surgery and a more thorough physical examination.

In general, all reptiles are covered with scales. They can have four legs, or none. There are no snakes with legs, but there are lizards without legs. Thus, it is important to be able to distinguish a snake from a legless lizard. Snakes do not have eyelids. Lizards and turtles do have functional eyelids (with some exceptions such as some members of the gecko family). The snake eye is protected by a transparent scale called the spectacle. When a snake goes through ecdysis, or shedding, it will slough this spectacle with its skin. Occasionally this spectacle will not come off with the skin, and results in a retained eye cap.

A second obvious difference between snakes and legless lizards is that snakes do not have external ears. But, to complicate matters, not all lizards have ears. Fortunately, all legless lizards do! The snake lacks not only the external ear, but also the middle ear cavity, tympanic membrane and eustachian tube. They do have an internal ear which functions in detecting motion, static position and sound waves which travel through the ground, and limited audio frequencies. Lizards and turtles lack external pinnae, but most have a conspicuous tympanic membrane. There are a few species of lizards which lack this feature.

Snakes and some lizards have a special sensory structure called the vomeronasal or Jacobson's organ. Its paired openings are just rostral to the choana. The flicking tongue picks up minute scent particles in the air and places them in direct contact with this organ.

The teeth of snakes and lizards are both acrodont (attached to the bone) and polyphydont (capable of having several sets throughout life). Turtles do not have teeth, but instead, they have a horny beak that they use for biting. Non-venomous snakes have four rows of upper teeth: two rows on the maxilla and two rows on the palatine-pterygoid bones. There are only two rows on the lower jaw, one attached to each mandible. Venomous snakes substitute fangs for the maxillary teeth.

There is a small opening caudal to the tongue called the glottis. Unlike mammals, the reptile glottis is always closed unless it is taking a breath. It forms a vertical slit in the closed position. Snakes are able to extend their glottis out the side of their mouth while they are eating to allow for respiration.

The trachea is usually long and is supported by cartilaginous rings. These rings are complete in the turtle and the crocodile, and incomplete in the lizard and snake. The trachea usually terminates just dorsal to the heart. In the lizard and turtles the trachea bifurcates into two bronchi which then enter the left or right lung. In the snake the trachea branches into a short left bronchus which terminates in a vestigial left lung. The size and functional capacity of this left lung varies from species, and can be complete in some of the water snakes where it is used for hydrostatic purposes. The right bronchus terminates in the functional right lung.

All reptiles, except the crocodile, lack a diaphragm. Breathing (inspiration and expiration) is accomplished principally by the intercostal muscles. These are assisted by other muscles of the trunk and abdomen, as well as smooth muscles in the walls of the lungs themselves.

The three chambered reptilian heart is composed of two atria and a large ventricle. There is an incomplete ventriclar septum which allows the heart to function as a four chambered heart.

Reptiles have a renal portal system. In the snake the parietal veins from the body wall and the caudal vein from the tail pass through the kidneys before anastomosing with the ventral abdominal vein. In the lizard the caudal tail vein and the internal and external iliac veins all feed through the kidneys before returning to the heart. In the turtle the renal portal system receives veins from the carapace, the musculature posterior to the kidneys and the external iliac veins.

Reptiles, except the snapping turtle, do not have lymph nodes. However, the lymphatic system in reptiles is complex. There is an extensive network of perivascular lymph channels around the major vessels and perivisceral lymph spaces which drain the viscera.

The spleen is a small, spherical, reddish organ located between the gall bladder and the pancreas. It is usually tightly adhered to the pancreas, and the two organs collectively are often referred to as the splenopancreas.

The pancreas is found caudal to the gall bladder on the mesenteric border of the duodenum. It has both endocrine and exocrine functions much the same as in mammals.

The single or double lobed thymus is found craniolateral to the thyroid gland, closely associated with the vagus. It does not involute when the animal matures as it does in higher vertebrates. Just caudoventral to the thymus is the thyroid. It is a spherical reddish-pink structure cranioventral to the heart and ventral to the trachea.

Reptiles have one or two pairs of parathyroid glands which can be found either cranial or caudal to the thyroid. In turtles the glands may be found imbedded in the thymus. These glands are difficult to find and are often obscured in the adipose tissue.

All reptiles have a pair of adrenal glands. They are found closely associated with the gonads and urogenital structures of the lizard and snake and with the kidneys in the turtle. The adrenals are pinkish filiform structures found medial to the gonads. Unlike mammals, the medullary and cortical tissue is indistinguishable, but nonetheless still produces the appropriate hormones.

For the most part the mouth does little more than catch the food. Very little mastication, if any, occurs. The saliva that is produced has little digestive significance, its role being mostly lubricatory. The esophagus has a special adaptation of several longitudinal folds which allow for great distensibility of the gut to accommodate large food items. The esophagus is dorsal to the trachea and extends from the pharynx to the stomach.

The stomach of the snake is fusiform, and in the lizard and turtle its shape grossly resembles the mammalian stomach. The stomach is rather short in the snake. Its junction with the esophagus is clearly noted at a site approximately equal to three-fourths the length of the liver. The stomach ends in a stricture, the pylorus, at the pyloroduodenal junction.

The small intestine may be either straight or have short transverse loops. The small intestine in the lizard and turtle has many loops and convolutions much the same as in the mammal. The small intestine terminates at the ileocolic junction. A cecum is present in some snake species. A cecum is present in both the lizard and the turtle.

The large intestine terminates at the cloaca. It is a short, straight tube. As in the bird, the reptilian cloaca has three chambers. The feces are discharged into the anterior chamber called the coprodeum. The next, or middle chamber, called the urodeum, receives the urogenital ducts. The posterior proctodeum acts as a general collecting area for digestive and excretory wastes. The male intromittent organs open into this compartment, and both the male and the female have scent glands that also open here.

The reptile has a metanephric kidney. It is situated in the posterior part of the body positioned adjacent to the body wall, with the right kidney anterior to the left. They are brown in color and consist of twenty-five to thirty lobes. Since the snake lacks a bladder the ureters enter directly into the urodeum. The lizard and turtle the ureters enter the bladder, which then empties directly into the urodeum.

Both the male and female gonads are found in the posterior half of the body. They are medial to the kidneys and in the snake, the right is cranial to the left. The testes are off-white to yellow, and the ovaries are a yellowish pink.

AMBIENT TEMPERATURE AND REPTILIAN PHYSIOLOGY

An increase in body temperature, or fever as it is referred to in mammals, has been noted to be beneficial to the health of the individual as far back as 2500 years ago. Although reptiles, which are ectotherms - that is, animals whose body temperature depends directly upon the ambient temperature or environmental factors such as the sun - are incapable of developing a fever response as can mammals, they can develop a fever behaviorally when exposed to certain pyrogens.

Fever in mammals, or its equivalent in reptiles, results when the thermoregulatory "set point" becomes elevated. The elevated "set point" is due to a response to a triggering agent such as a bacteria or virus. After the arrival of the foreign substance in the body the host's macrophages release a hormone called an endogenous pyrogen (EP). The EP acts directly on a region in the brain, the hypothalamus, the portion of the brain generally thought to be responsible for thermal regulation.

In mammals this increase in "set point" is manifested by increasing metabolic heat production (shivering), surface vasoconstriction and behavioral means. Reptiles depend entirely on behavioral means of thermoregulation.

Specimens of Dipsosaurus dorsalis, the desert iguana, were placed in cages which had a temperature gradient ranging from 30 - 50C. Lizards injected with a bacterial containing solution consistently chose a temperature that was 2C warmer than non-infected lizards. The lizards began to seek the warmer temperatures within four to six hours post-infection.

The antibody response of Dipsosaurus dorsalis, which had been infected with Salmonella typhosa, was evaluated at different ambient temperatures. At various intervals post-immunization agglutination titers were run to determine the antibody response. The antibody response was poor to non-existent at 25C,

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good at 35C, and moderately good at 40C. It was also noted that if the lizards were immunized at 35C and then transferred to 25C the antibody response was inhibited, but if moved from 35C to 40C after immunization the antibody response was enhanced.

During infection in mammals serum iron falls due to a release of EP. Bacteria uses the iron as a growth factor. The ability of bacteria to utilize iron is diminished at elevated temperatures. This fact, coupled with the drop in serum iron by the host, makes growth and continued propagation difficult for the bacteria.

Leukocyte activation, including increasing phagocytic, bactericidal and viricidal activity, leukocyte mobilization, and augmented production of immunologically active T-cells, are all factors that are increased by the release of EP. EP also stimulates interferon, an antiviral agent elaborated from the host's cells.

Elevated temperature, in and of itself, has a direct effect on viral and bacterial kinetics. Studies done on viral activity in the pig, ferret and puppy show that the virulence of viruses is attenuated at elevated body temperatures.

There are a combination of factors, due to elevated ambient, and hence, body temperature, work synergistically to help fight infection. The augmented antibody response, the increase in leukocyte activation, the stimulation of interferon and lysosomes, the decrease in serum iron and the decreased effectiveness of the bacterial siderophores combined with the actual decreased growth and replication of the bacteria and viruses represent a coordinated effort by the host to overcome disease.

References available on request.

THE REPTILIAN HEMATOCRIT ANALYSIS

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There are two major challenges thwarting laboratory testing in reptilian patients: first, collecting the sample, and second, interpreting the results. Many of our patients are tiny, making both the physical act of collection difficult, and, severely limiting the amount of blood collected.

Blood volumes in reptiles vary from five to eight percent of their total body weight. Of this amount, up to ten percent in a healthy patient can be safely collected for analysis without harm. As a rough approximation, the sample size should never be larger than one percent of the animal's total body weight. For example, in a 450 g corn snake you can safely collect 4.5 cc's of blood. This is way more than required by even the most antiquated autoanalyzers.

The standard capillary tube holds 70 ul. That means that the volume of a single capillary tube is the maximum amount of blood that you would want to take from any patient weighing a minimum of seven grams. Even though this is a small sample, there is enough to yield some valuable diagnostic information.

Packed Cell Volume (PCV) - The hematocrit tube is easily centrifuged to evaluate the percentage of RBC's:total collected sample. Comparing this to known values, a diagnosis of anemia or dehydration can be calculated.

Total Solids - All exotic samples should be collected in a lithium heparinized capillary tube. Using a refractometer the total plasma or serum protein can be estimated under the guise of Total Solids. Note, since reptiles have an abundance of solids in their plasma, the refractometer method is not completely accurate. However, this measurement will be beneficial in interpreting the PCV to determine anemia vs. dehydration, etc. In addition, it is a valuable measurement when monitoring fluid therapy and response to treatment.

Icterus Index - It is not uncommon for reptile patients to have a yellow tinge to their plasma. All color changes should be noted. Green plasma, secondary to hyperbiliverdinemia, is seen in catabolic states (such as in starvation, toxemia, heat stress). Lipemic plasma is also readily detected in plasma samples. This is important to note when interpreting chemistry values reported by automated samplers.

Microfilaria - It is not uncommon to see circulating microfilaria in the area of the buffy coat in wild caught animals. Although the presence of microfilaria does not necessarily mean clinical disease, it is often an indication of the state of health of the animal. The blood parasites are readily seen using the 10X objective.

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Thrombocytes - In mammals, the platelets collect at the top of the buffy coat layer, appearing as a cream colored layer as opposed to a light gray of the WBC's. The visible presence of this layer suggests adequate numbers of platelets. Look for this layer in the reptilian hematocrit.

White Blood Cells - In mammals the first 1% (1% of the total hematocrit count) represents approximately 10,000 WBC/ul. The second percent represents an ADDITIONAL 20,000 WBC. For example, a 2% buffy coat, would suggest an estimated total WBC of 30,000 WBC/ul (10,000 for the first 1%, 20,000 for the second 1%). A similar study has been performed in a limited number of herp patients, and the parallels do not seem similar. However, this estimation can be a guide when evaluating patients. There is ample room for error in this method and it should just be used as an approximation.

Buffy Coat Smears - If the hematocrit tube is snapped at the BC, the concentrated WBC's can be easily smeared and evaluated for the presence of parasites, inclusions, toxic changes or degranulation.

RBC health/O2 saturation - Color of the RBC's speaks of RBC health, age, oxygen saturation and toxicity. A patient presenting with respiratory signs that has nice red blood has less pulmonary compromise than a similar patient with dark purple blood. Likewise, brown coloration may suggest toxicity.

Blood smear - If a single drop of blood is utilized to make a smear before the hematocrit tube is centrifuged, a differential can be performed. In addition, overall cellular morphology can be assessed and a more thorough estimated WBC can be determined.

After the cells have been spun down the remaining plasma can be used for a limited number of specific chemistries (e.g.. uric acid, calcium, phosphorus)

In reality, with the very small patients, only a single drop of blood might be all that you will be able to safely collect. A thin, well prepared blood smear will always be of value as a diagnostic aide.

Even if you send your reptilian samples to an out lab, I STRONGLY RECOMMEND THAT YOU ALWAYS KEEP ONE HEMATOCRIT TUBE FOR IN HOUSE ANALYSIS!

References available on request.

TREATMENT TECHNIQUES IN REPTILE PATIENTS

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There are a lot of similarities between small animals and reptiles. That said, there are also differences, but these differences can make a difference between treament success and failure when not heeded.

The FUNDAMENTAL principle to be followed when treating reptiles is to make sure that they are at their Preferred Optimal Temperature when administering treatments. The Preferred Optimal Temperature Zone (POTZ) for numerous reptile species can easily be found in the literature or on line at a number of sites.

When a reptile is at its POTZ the response to medications can be predicted – as they tend to respond like a mammal when properly warmed. When their core body temperatures are too low, there is no way to anticipate how their ill bodies will handle the medication.

It is the rare reptile patient (exceptions are severe traumas) that cannot wait 12 – 24 hours to be properly warmed up and prepared for diagnostics and therapeutics.

ADMINISTERING MEDICATIONS

Before administering any treament to an ill reptile you should always take the patient's core body temperature. This is done in a fashion similar to the procedure in mammals. Caution should be taken when inserting the thermometer in the vent as there is a blind pocket in the cranial portion of the cloaca (the corprodeum). This is easily, accidentally, penetrated, when using a pointed or sharp plastic thermometer. Soft, flexible, electronic thermometers are the best to use.

Oral route (PO)

There is an old addage in small animal medicine that "if the mouth works, use it." I believe that this is true in reptiles as well. Of course, you have to remember the caveat – they have to be properly warmed.

There has always been a belief that you should not use oral medications in herps. It has been shown that oral medications work fine in the properly prepared patient. Even if the patient is aggressive, has facial injuries or just can't be manipulated, it is still possible to place an esophagostomy tube and is commonly done is chelonians, and occasionally lizards and crocodilians. Snakes are generally easy to tube and E-tubes are rarely warranted.

This author prefers to send home reptile patients on oral medications rather than injectable drugs. When the owner is properly prepared and the patient is properly maintained, oral medications are an effective and safe way to prescribe home therapy.

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Subcutaneous (SC)

Reptiles don't have the voluminous SC space that is seen in mammals. More importantly, the SC space is not well vascularized in herps, making administration of medicaitons in this location less efficiently absorbed.

Snakes have a SC lateral sinus that runs along the entire side of the animal. It is readily found between the epaxial muscles and the top of the ribs. When entered with a needle the fluid medication (chemotherapeutics or fluids) readily runs along this space down the side of the patient. By utilizing this space you minimize the obvious stretching of the skin seen with SC injections and theoretically, decrease any potential pain associated with administration of larger volumes of fluids.

In squamates there is generally an obvious lateral skin fold extending from just cranial to the thigh to the axilla. In most lizards there is minimal SC space between the scapula, a site commonly used in mammals, and is not recommended.

In chelonians, if it is possible to access the axillary or prefemoral regions, there is ample SC space for administering fluids or injections. Some chelonians will withdraw into their shell making access difficult. It may be possible to administer SC by using long needles inserted between the limb and the shell, but, this is not recommended as there is no way to adequately prep the skin before the injection.

Crocodilians can be administered SQ fluids along their lateral body wall similar to lizards.

Hyaluronidase (an enzyme derived from bovine testicular tissue) administration has been advocated for enhancing SC fluid absorption in various species, including reptiles. Hyaluronidase lyses hyaluronic acid, which is part of the ground substance that binds the interstitium. In humans, it has been used for facilitating fluid and drug absorption from the subcutaneous space and reducing pain during chronic fluid administration. However, studies performed in cancer patients found no comparable difference between the duration of fluid at the administration site or the presence of pain in patients who received hyaluronidase during chronic subcutaneous fluid administration to those who did not. No studies have been performed to advocate its use for fluid replacement in the reptile.

Finally, regarding SC administration of medications in herps, some drugs are irritating or have extreme pH values have been shown to cause scarring and depigmentation to the skin post treatment. Clients should be warned of this possibility.

Intracoelomic (ICe)

Ice fluid administration is commonly performed in reptile patients. Again, if the patient is properly warmed, this route can be effective, especially for larger amounts of fluid.

Caution should be taken to avoid damaging internal structures when inserting the needle. Gently placing the patient in dorsal recumbency, with the head angled slightly down, allows the viscera to slide forward with gravity, providing a small target just ventrocranial to the thighs. If the needle is directed parallel to the body wall and aimed slightly ventrally, it is less likely that organs, or lungs and airsacs, may be entered.

- Always aspirate before administering – if blood, air or any fluid is withdrawn, remove the needle, and start fresh with a new syringe of medication.

Intramuscular (IM)

Before a discussion of IM injections locations is covered it is necessary to have a brief discussion on the reptilian Renal Portal System (RPS) and Hepati Portal Sysem (HPS).

Many of the drugs, especially the antibiotics, that are used in reptile patients are eliminated via the kidneys. Historically, authors have stated that drugs should not be administered in the caudal half of a reptile's body in order to avoid the RPS. Thoughts have concentrated on the fact that either the drugs would suffer a first pass effect (and subsequently be rendered ineffective) or, enter the kidneys in such high concentrations that renal toxicity might be a concern (especially with drugs such as the aminoglycosides).

Studies on the RPS in chelonia (Holz and Lewbart) have demonstrated a difference in the plasma concentrations of certain drugs when administered either in the forelimb or the hindlimb musculature. In one study, there was a significant difference between the two injection sites for the drug cephazolin, a drug known to be cleared by tubular secretion, but not gentamicin, a drug that is cleared by glomerular filtration.

In regards to the significant decrease in blood levels for the former drug, the author speculated that there was in fact no clinical significance since, although the levels had dropped, they were still above the MIC necessary for successful therapy.

The conclusion here was that drugs eliminated via tubular secretion may be affected by the RPS, owing to the fact that the blood returning from the caudal limbs and the tail appears to course through the kidneys prior to returning to the systemic circulation. Drugs cleared from the body by glomerular filtration were not affected, apparently because the blood bypasses that anatomical location.

In reality, that is a gross oversimplification. Blood may change flow in and around the RPS dependent on many different factors. Body temperature and hydration status are the main two determinants. In addition, there are 10,000+ species of reptiles, and hundreds of medications that have yet to be studied. The work done so far is an important first step in understanding the black box of therapeutics in reptilian patients, but, caution must be taken when making generalizations. If necessary, it would be best to err on the conservative side, and if any doubt exists regarding the best administration site for a given medication, the cranial half of the patient's body should be chosen.

Medications that are conjugated and elimated via the liver should also be administered via the front legs to avoid a first pass effect (the HPS). Studies looking at sedatives administered via the rear legs have shown diminished effect when compared to giving the same dose of the drug in the front legs.

Remember, when giving medications by the IM route the patient must be properly warmed prior to administration. IM sites are limited in snakes to the epaxial muscles along either side of the spine. In some emaciated, or very small animals, this can be challenging and the injections are often SC rather than IM.

- In lizards IM sites include the epaxial muscles as in snakes, the quadriceps and triceps. I try to avoid the caudal thigh so as not to accidentally traumatize the sciatic nerve. I have seen animals develop paresthesias in the rear feet secondary to ketamine and enrofloxacin administration in the biceps femoris group.

Although theoretically IM injections can be administered into the large tail muscles in the larger lizards, I generally don't use this site. I had one case in a Water Dragon where calcium gluconate was given into the tail, and within a week the tail sloughed off distally to the injection site.

Several medications can be irritating or even caustic. For example, enrofloxacin (Baytril) has a pH of 11. It is only labelled for a SINGLE IM injection. When given IM it can cause severe muscle necrosis and sloughing of the skin.

IM injection in crocodilians are similar to those given in lizards.

In chelonians, again, the limiting factor is access to the limbs. If possible, for the appropriate medications, this author prefers the quadriceps or pectoral muscles. The large pectoral muscles, just under the front legs and dorsal to the plastron, are an excellent place for IM injections. There is generally a large muscle mass present and minimal critical structures present that may cause potential injection site complications.

Intravenous (IV)

The IV route is preferred in life-threatening conditions. Hypothermia and dehydration will not interfere with systemic absorption when drugs are given IV. That said, remember that whenever possible, the patient should be properly warmed, or at least in the process of being warmed, when IV therapy is started.

IV administration is possible in snakes but is limited. Intracardiac administration is possible in emergency situations – caution being taken not to administer medications that could be caustic to the myocardium. In addition, IV administration can be performed into the ventral coccygeal tail vein or the jugular vein. If a continuous IV is needed or if repeat IV administration is warranted, placing a jugular catheter is advised and not difficult.

The dorsal palatal vein is readily visible in snakes, and theoretically, can be used for IV access. But, extreme caution should be taken as this vein tends to bleed excessively and, especially in a conscious patient, can be difficult to establish adequate hemostasis. I do not recommend using this vein unless the animal is under general anesthesia.

In lizards IV medications can be given in the ventral coccygeal vein or the jugular veins. It is possible to utilize the brachial veins or the femoral veins in larger animals, but, they are surrounded by nerves and lymphatic channels, making placement difficult if not risky.

Again, if repeat IV access is needed, placing an IV catheter is recommended. The jugular veins or the cephalic vein in larger lizards are the preferred sites.

This author adamantly recommends against using the ventral abdominal vein due the risk of accidentally penetrating abdominal viscera thus resulting in iatrogenic ceolomitis.

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Intraosseous (IO)

Administering medications via the IO route are generally limited to fluid therapy via an IO catheter. Caution should be taken not to administer any medication IO that may be caustic to the bone marrow.

IO catheters are generally placed into either the proximal tibia, throught the crest, directed distally into the tibia. Alternately, some clinicians prefer to enter the femur since it is a larger bone, entering the femur just proximal to the stifle and directing the needle proximally toward the hip. I caution against this technique, especially in species with a patella.

Finally, IO placement generally requires general anesthesia as it is painful, and, if not properly prepped and maintained, can result in permanent damage to the bone (osteomyelitis) and joint if it is accidentally penetrated during placement. I recommend attempting IV placement prior to IO access.

References available on request.

ANTIBIOTICS COMMONLY USED IN REPTILES

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Most of the antimicrobial research in herps has been limited pharmacokinetic, NOT pharmacodynamic studies. What that means is that although several drugs have been evaluated in several different herp species, only drug levels and suggested dosages have been evaluated, NOT the actual effect on the patient or the pathogens within the patient. Also to note, what little information that is available shows that different species respond differently to the same drug at the same dosages. So we may know, based on limited research, that you should give a snake a loading dose of 5.0 mg/kg of Amikacin, followed by 2.5 mg/kg every 72 hours, we actually have no idea what effect it has on the animal's physiology or even it is going to work to rid the infection.

That stated, we have to start somewhere. I'll discuss the drugs I use most commonly in my practice. For the most part, these drugs have pK studies to back them up.

There are a number of factors that must be considered when choosing an antibiotic. The results of microbiological culture and sensitivity testing, the species being treated, physical condition of the patient, frequency of administration, cost of the therapy, owner compliance, and a host of other factors are all important.

The veterinary clinician must have a thorough understanding of reptile physiology and biology prior to administering medications. Since all reptiles are ectotherms, and their metabolism is temperature dependent, they will often react unpredictably to the same drug in different settings. A good working knowledge of the more common species of reptiles, their life histories and their peculiarities will help prevent potential disasters during therapy.

GENERAL CONSIDERATIONS

Before treatment is initiated the patient should be given a thorough exam including a CBC and serum profile, with a uric acid, to assess hydration status. Dehydrated or hyperuricemic patients should be properly rehydrated prior to initiating therapy. It is the rare case that cannot wait one to two days to assure appropriate hydration prior to treatment. However, if for some reason treatment must be instigated immediately, it would behoove the practitioner to choose a non-nephrotoxic drug.

Another important consideration is the ambient temperature of the reptile's environment. Pharmacokinetic studies have shown that an increase in ambient temperature tends to increase both the volume of distribution and body clearance of the drug. A decrease in ambient temperature with a resultant decrease in body clearance could potentially allow a build up in concentration of the drug to a point where it might reach toxic levels if dosing is not decreased accordingly.

When reptile pathogens are treated at higher temperatures the Mean Inhibitory Concentration (MIC) needed to achieve effective treatment significantly decreases. This allows for a lower dose of antibiotic to be given, another positive factor when dealing with potentially nephrotoxic drugs.

Most researchers feel that it is best to treat sick reptiles near the higher end of their preferred optimum temperature zone. Not only is it beneficial for reasons already mentioned,

but elevated ambient temperatures have been shown to stimulate the host's immune system and aid in fighting disease in other ways already discussed.

When selecting the appropriate antibiotic it is important to consider the status of the host's immune system. In critically ill or immuno-compromised reptiles, bacteri*cidal*, rather than bacterio*static* antibiotics are preferable. In cases of gram negative sepsis, especially with *Pseudomonas* infections, the reptile patient is often severely immunocompromised.

In many cases the animals are infirmed because they have been immunocompromised due to improper husbandry conditions. The most common cause is from being maintained at suboptimal environmental temperatures.

Methods of administration

There are very few instances where oral antibiotic therapy is required. Enteric infections often warrant oral administration of appropriate drugs. There are two common methods for administering oral antibiotics. If the patient is still feeding, the antibiotic can be mixed with the food or injected into the dead prey and fed to the animal. Gavaging, or stomach tubing, is a second technique which can be used to administer oral medications.

Topical anitbiotic therapy

Although oral dosing of systemic antibiotics is not commonly done, it is not uncommon to actually treat the oral cavity itself. This is often done in cases of severe Infectious Stomatitis where the oral cavity is abscessed. Since the vascularity to an abscessed oral cavity is usually compromised, antibiotics given systemically may not be able to reach adequate therapeutic levels in the infected tissues. Aminoglycoside antibiotics have decreased activity in anaerobic or acidic environments. When treating with a drug like enrofloxacin systemically you can also use topical flouroquinolone on the lesions in the oral cavity. Daily application of Ciloxin® ophthalmic solution, one drop on each affected area, works well.

Silvadene® is a soft, white, water-miscible cream containing the antimicrobial agent silver sulfadiazine. This bactericidal cream is effective against a broad range of both gram positive and gram negative bacteria, including *Pseudomonas aeruginosa*, as well as some of the yeasts. Silvadene® is easily applied with a cotton tipped swab or other applicator. A dressing is not necessary unless the area being treated is in a location where the cream may be rubbed off. Otherwise, the cream will last for two to three days before a new application is required.

Injectable antibiotic therapy

Injectable antibiotics are probably the best form for assuring proper delivery of the drug. The antibiotics are either injected intramuscularly, or less commonly, subcutaneously. The intravenous route is often limited by the availability of venous access. The size and species being treated will determine whether intravenous infusion is possible.

Reptiles have an anatomical variation called the renal portal system. Blood leaving the tail and pelvic limbs passes through the kidneys before returning to the heart. When administering antibiotics which are either cleared by the kidney or are potentially nephrotoxic, the hind limbs and tail should not be used. Antibiotics excreted from he body via glomerular filtration bypass this renal portal system. Antibiotics that are secreted by the peritubular capillaries are affected and have the potential of a decreased ciruclating concentration if the

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medications are injected into the rear legs or the tail. The renal portal system can be avoided by making all injections in the cranial half of the body.

An important consideration when selecting an antibiotic is its ability to penetrate the target tissue site. In cases of severe Infectious Stomatitis, the vascular supply may be compromised to the oral cavity in the area of the lesions. This may prevent good penetration of the antibiotic to the site of infection.

Another method of assuring adequate antibiotic levels to the affected tissue is to calculate the total systemic dose, draw it into a syringe, and then add an equal volume of bacteriostatic water to dilute it out to half concentration. Inject three-fourths of the dose intramuscularly, and the remaining quarter dose directly into the region of the mouth where the infection is present. If you need to inject in more than one place in the mouth it is a good idea to switch needles to prevent seeding of bacteria from one site to another.

Renal and Hepatic Portal Systems

Reptiles have both renal and hepatic portal systems. Thus, unless it is known how the particular drug is cleared from the body, it is best to use the front half of the body when administering systemic medications.

Fluid therapy

Since reptiles are uricotelic, that is, they excrete uric acid as the end product of protein metabolism, they are readily susceptible to visceral gout. If the patient is dehydrated or develops renal pathology due to treatment with nephrotoxic drugs, the insoluble uric acid forms microcrystals called "tophi" on the serosal surfaces and within tissues such as the heart, lungs, liver and kidneys.

Visceral gout can be prevented by utilizing proper drug dosages, evaluating the patient's hydration status and monitoring blood uric acid levels throughout therapy. A follow-up blood uric acid should be checked one to two weeks after the treatment is finished.

The patient should be supplemented with physiologic fluids at 15-25 ml/kg on the days it receives antibiotic treatment. The fluids can be given orally, intracoelomically, or subcutaneously in the lateral sinus. The latter is located at the junction between the epaxial musculature and the ribs.

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TABLE 1 - Common bacterial isolates, their pathogenicity and the antimicrobials recommended.

ORGANISM	PATHOGENIC†	ANTIBIOTIC CHOICE*
Acinetobacter spp.	+++	A, F
Actinobacillus spp.	+++	A, F
Aeromonas spp.	++++	A
Bacteroides	+++	P, C, M
Citrobacter freundii	++++	A, F
Clostridium	+++	P, C, M
Corynebacterium spp.	++++	P, C
E. coli	++	A
Edwardsiella spp.	+++	A, F
Enterobacter ssp.	+++	A, F
Klebsiella spp.	++++	A
Micrococcus spp.	No	F, C
Morganella spp.	++++	A, F
Mycobacteria	++++	Tx not recommended
Pastuerella spp.	+++	F
Proteus spp.	++++	F
Providencia spp.	+++	A
Pseudomonas spp.	++++	A
Salmonella	? to ++++	Tx questionable
Serratia spp.	++++	A
Staphylococcus spp. coagulase positive	+++	F, C
Staphylococcus spp. coagulase negative	NO	nn
Streptococcis spp. alpha-hemolytic	NO	nn
Streptococcus spp. beta-hemolytic	+++	F, C

†(+)not pathogenic; (+) to (++) opportunist to varying degress of pathogenicity; (++++) pathogenic

*Tx - Treatment; nn - none needed; A - Aminoglycoside; C - Cephalosporin; F - Floroquinolone; M - Metronidazole; P - Penicillin

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Table 2 - 10 Steps for Rational Antimicrobial Use (Antibiotic Stewardship)

1. Initial assessment - Always perform a proper, thorough physical examination, including evaluation of the animal's state of repletion (starvation plays a significant role in antibiotic choice due to catabolic effects and an increase in uric acid production), and hydration.
2. Warm the animal up to its POTZ (it is the RARE case that cannot wait for the patient to be properly warmed prior to initiating antibiotic therapy). Monitor the patient's body (cloacal) temperature.
3. Fluids as needed.
4. Diagnostic sample collection - blood for (CBC/chem, culture), urine (microscopic analysis, culture), specific specimen cultures (lung wash, cloacal or colon wash), aspirate of masses, etc. (if possible, obtain blood samples prior to fluids).
5. Determination of method of administration (oral, systemic, topical). Coordinate your choice with owner experience/compliance.
6. Choice of drug - general vs. specific, single drug vs. combination therapy - see later.
7. Adjustment of dosages (correction for dehydration, renal function, bacterial culture and sensitivity results, etc.).
8. Proper follow-up and patient monitoring (recheck and progress checks, serial uric acid measurements).
9. Author's first drugs of choice: amikacin (caution renal patients), ceftazidime, enrofloxacin, trimethoprim-sulfa.
10. Drugs for combination therapy: metronidazole, piperacillin. Example, combine amikacin with metronidazole.

References available on request.

FLUID AND ANALGESICS USED IN REPTILES

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Objectives –
1 – Understand which fluids are best to use in reptile patients
2 – Be able to recognize signs of pain and discomfort in the reptile patient
3 – Know which analgesics are best for the painful reptile

FLUID THERAPY

The most important thing to remember when administering fluids to ill reptiles is that if the mouth works – use it. All too often veterinarians rush to administer fluids subcutaneously, intracoelomically or intraosseous. In many situations oral fluids are just as effective, and in some cases, more so.

All reptile patients must be maintained at their preferred optimum temperature in order to process and efficiently utilize supplemental fluids – regardless of the route of administration.

The principles of fluid therapy are universal across species lines. A basic understanding of body water distribution, forces governing water movement between fluid compartments, fluid pharmacology, and patient assessment are necessary to determine the fluid type, dose and rate of fluid to be administered. The physiologic properties of water in normally hydrated reptiles is comparable to that of other vertebrates.

There are three basic types of crystalloids:
Isotonic fluids - Osmolality = erythrocytes (Does not promote fluid exchange)
Hypotonic fluids - Osmolality < erythrocytes (Increases erythrocyte volume)
Hypertonic fluids - Osmolality > erythrocytes (Decreases erythrocyte volume)

The three most common types of fluids used in the United States are Lactated Ringer's Solution, Normosol – R and Plasmalyte. These fluids are all considered isotonic.

A fourth fluid, which is a combination of several different fluids was published many years ago, is called Reptile Ringer's This hypotonic fluid was popular for a few years but has fallen out of vogue as more has been learned about fluid and electrolyte balance in reptiles.

Of importance to note regarding these fluids is their ability to act as physiological buffers.

LRS & Reptile Ringers = Lactate
Lactate -> bicarbonate via Liver
Normosol-R = Acetate
Acetate -> bicarbonate via muscle
Plasmalyte = Gluconate
Gluconate -> bicarbonate via all cells

Historically there has been some controversy that *Lactate* in LRS will exacerbate Hyperlactatemia in Reptiles (as seen in dehydration). Reptiles use anaerbic metabolism and

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can tolerate high levels of plasma Lactate. Therefore, Lactate salts in LRS *DO NOT AFFECT* plasma Lactate levels (unless there is end-stage liver disease).

In summary, There is *NO ONE FLUID* that is universal for all reptile patients ! It is recommended that fluid choices are based on laboratory sampling and electrolyte analysis.

See notes in these proceedings under "ER Techniques in Reptiles and Small Mammals" for a discussion on administering fluids and placing IV catheters.

ANALGESIC THERAPY

Treating pain in animals is a fundamental part of what veterinarians do. The idea of addressing pain in reptile patients has only recently been discussed. Although there are a lot of anecdotal reports for treating pain in reptiles, in fact, only a few actual studies have been performed. Before any attempt is made to determine the best way to treat pain in reptiles, it is imperative that we learn to recognize pain

UNDERSTANDING PAIN IN REPTILES

We have to assume that reptiles feel pain. But, how? There have been studies looking at receptor sites. Reptiles have the same neurologic and receptor sites as do mammals, but clinically they don't seem to show similar responses. Why does the snake allow the mouse or rat to bite and not respond? Why does the iguana fall asleep under a heat lamp and suffer a third degree burn, only to wake, walk away and go eat?

There are established pain scales for mammals. There are no similar objective standards for evaluating pain in reptiles. Many of the signs that we associate with pain can also be attributed to other causes. Such as, anorexia – common in mammals with pain – can also be cause in reptiles by something as simple as hypothermia.

In a survey by Matt Read members of the Association of Reptilian and Amphibian Veterinarians were asked if they felt that reptiles felt pain. 98.4% responded yes. In addition, they were asked how many used pain medications – surprisingly, only 39.5% of the respondants said they use analgesics in their reptile patients. When asked what was the most common analgesic that they used, the answer was butorphenol.

ANALGESIA STUDIES IN REPTILES

Greenacre et. al. evaluated the effects of opoids in the Green Iguana. 5 animals were administered electrical shocks but were pre-treated with either butorphenol, buprenorphine or morphine. There were differences noted in between control (saline) groups and animals receiving 1.5 and 8.0 mg/kg of butorphenol, but not for 0.4 or 4.0 mg/kg.

There were no differences noted between saline groups and those given buprenorphine.

Morphine pre-treated animals showed a depressed response to the shock at 1.0 mg/kg, but not at 0.4 or 2.0 mg/kg.

Sladky e. al. looked at the antinociceptive and respiratory effects of butorphenol and morphine in three reptile species (Red-eared Sliders, Bearded Dragons and Corn Snakes). The subjects were pretreated with either butorphenol (a kappa agonist) or morphine (a mu agonist). Each subject was then subjected to an infrared heat stimulus and

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the response was measured. In addition, effects of each drug on the respiratory efforts were also evaluated.

Butorphenol showed no analgesic effects against the infrared stimulus. Morphine did show a depressed reaction the stimulus. Both butorphenol and morphine demonstrated respiratory depressive effects.

One study has been performed using NSAIDS in reptiles. In that study Ball Pythons were pre-treated with meloxicam, 0.3 mg/kg, SC prior to surgical catheterization. Various physiological parameters such as plasma catecholamines, cortisol, blood pressure, heart rate and blood gas values. Per the authors, there was no significant difference between snakes that received meloxicam compared to a saline control. NSAIDS may have a place in treating acute and chronic pain in reptiles, but safe, effective doses need to be established, and caution must be taken regarding renal function and gastrointestinal effects as seen in mammalian patients.

In a recent study presented at the 2011 ARAV annual meeting, C. Mans stated that hydromorphone at 0.5 mg/kg, SC, provided thermal nociception for up to 24 hours, whereas buprenorphine at 0.2 mg/kg, SC did not.

CONCLUSION

To date there have been no definitive studies in reptiles that demonstrate what would be the best analgesics. Practitioners should use care when selecting analgesics based solely on limited experience in the various species. In my hospital I use meloxicam at 0.1 – 0.2 mg/kg, IM, q 24h and hydromorphone at 0.5 mg/kg, IM, q 24h prn.

References available on request.

COMMON MEDICAL PROBLEMS IN BEARDED DRAGONS

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Depending on the reference source, the central Bearded dragon (*Pogona vitticeps*) which is native to Australia, is either the most popular pet lizard, or at least in the top three. Regardless of where they rank in sales, because of their great personalities, hardy dispositions and ease of care, most people agree that they are one of the best reptile pets on the market. Because of their popularity, Beardies are commonly presented to veterinarians for care and advice.

HUSBANDRY

Beardies are diurnal, omnivorous and social animals. They are simple to care for and seem to "enjoy" being around people, making them great for first time reptile keepers.

The wild or native Dragon is a patterned sandy brown with rough skin and covered with small spines along their sides and chin. Both the male and female have a protrusible "beard" that is extended when displaying aggression (rarely seen in captives). When stressed or ill the beard will turn black.

These animals reproduce easily in captivity and selective breeding has produced about a dozen different "morphs." Simple changes in color are referred to as "Fancy's," but animals further from the norm, specifically referring to obvious changes in the skin, spines and claw types, are classified into one of several morphs. Examples of common morphs include the Leatherback, Silkback, Hypomelanistic, Translucent, Zero and German Giant.

In the wild a Beardies lifespan is around 10-15 years, but, there are reports of animals in captivity living past 20 years. Full grown they rarely reach two feet long tip to tail allowing them to live comfortably in a 75-gallon terrarium.

Dragons do like to climb. Large rocks and stout branches should be available as cage enrichment. These items will also aid the Beardie during times of ecdysis.

Sexes appear similar in appearance, but, mature males do have larger femoral pores under their thighs than similar sized females. Beardies do well being housed solo. When housed together, especially in small cages, Dragons may fight and cause severe wounds to their conspecifics.

Young Beardies should be housed on newspaper, paper towels or reptile carpet. The latter looks and feels like grass and is easily cleaned and disinfected. Young animals tend to eat substrate, especially if food gets mixed into it, and impactions can ensure. Adult Dragons can be maintained on reptile carpet or plain dirt. Again, avoid sand as it can cause impactions if consumed.

Beardies are acclimated to warm temperatures. Their housing should have a thermal gradient established where the cool side of the tank is around 85ºF progressively increasing to a basking spot on the opposite side in the range of 95 -110 ºF. "Hot spots" for basking can be created with either a basking light or ceramic heat emitter. Nighttime lows should not be less than 65ºF.

If housed indoors, these diurnal lizards require full spectrum lighting (UV-B, wavelength 290-320nm) for 12 - 14 hours a day, preferably paralleling natural daylight changes. The lights should be inside the cage and not directed through glass.

Being omnivores, Beardies do well on a diet of both animal and plant protein. Juvenile Dragons should have a ready supply of baby gut loaded or vitamin dusted crickets. A small dish of finely chopped mixed vegetables, generously misted with water, should be available at all times. Any food left over at the end of the day should be discarded and replaced with fresh the following morning.

Sub-adult to adult Beardies can be meal fed once daily to every other day as they age. Along with fresh vegetables, vitamin/mineral supplemented adult crickets, Locusts, Cockroaches, Waxworms, Mealworms, Silkworms, Butterworms, Red worms, Earthworms and Zophobas are all well accepted. Lightening bugs have been shown to be toxic to Dragons and should be avoided.

Regarding the offered veggies, Chopped leafy greens like Romaine lettuce, Yellow, Spaghetti or Acorn squash, Green beans, Parsnip, Sweet potato, Snow peas and finely diced carrots can all be used in rotation. Fruits are primarily sugar and water and should be avoided, especially in young growing Dragons.

Water should be available at all times. Placing a large shallow bowl in the cage is a great way to offer a drinking source as well as a place for the Beardie to soak. All veggies should be washed and misted prior to being offered. Finally, misting the cage walls, or even gently, directly on the animal itself, will also provide necessary hydration.

COMMON MEDICAL CONDITIONS

As with most reptiles, Bearded Dragon morbidity is often related to improper management and nutrition. If the above guidelines are followed these animals tend to prove to be hardy pets. That said, there are some common presenting conditions that practitioners should be familiar with.

Nutritional Secondary Hyperparathyroidism
(AKA Nutritional Metabolic Bone Disease - NMBD)

NMBD is one of the most common disease conditions affecting captive REPTILES, especially lizards. Insectivores and herbivores need the correct combination of dietary vitamins and minerals (Vit. D, Ca^{++} and Phos) as well as UV-B exposure and appropriate ambient temperatures or they may succumb to this management caused morbidity. Young, growing Dragons and adult egg producing females are especially susceptible owing to their increased demand for dietary calcium.

Immature Dragons suffer from typical signs of fibrous osteodystrophy such as rubber jaw, spongy thickening of the long bones, deformed skeleton and pathological fractures. Both juveniles and gravid females can also present with hypocalcemic tetany.

If caught early and husbandry deficiencies are corrected this condition can be reversed. Advanced stages of disease can also be managed but deformities to the skeletal system may never resolve. Females often need to be spayed to prevent future events. Proper husbandry and diet are paramount to prevention and maintenance.

Periodontal Disease

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Like dogs and cats, Bearded Dragons also suffer from dental disease. Beardies have acrodont teeth, meaning that they are adhered to the ridge of the jawbone without sockets. When broken off they are not replaced. It is not uncommon for older Dragons to present with only a bony ridge remaining as their surface for mastigation.

Periodontal disease, as in companion mammal pets, may present as a loss of appetite, gingivitis, oral bleeding, tooth loss or dysphagia. It is not known why Dragons seem to be overrepresented with this condition (as opposed to other lizards), but diet has been suspected, as this has not been reported in wild conspecifics.

Just as in dogs and cats, treatment consists of proper dental scaling, extracting diseased teeth as needed, antibiotics and analgesics. Prognosis is good if caught in time, but animals left untreated will eventually die, usually of sepsis and inanition.

Atadenovirus

Typically associated with neonates and juveniles, this viral disease causes typical "sick lizard" signs such as anorexia, diarrhea, lethargy, wasting, failure to thrive or grow and neurologic symptoms. Adults are also susceptible but not seen as frequently as the younger animals. Subclinical carriers are suspected but it is also believed to be passed vertically through the egg.

There is no treatment available and the prognosis is grave. The intestines, pancreas, kidneys and liver are most commonly affected, with the latter showing evidence of severe necrosis on histopathological analysis.

Antemortem diagnosis can be made via PCR testing. Positive animals should be isolated and culled to prevent transmission to conspecifics.

Coccidiosis

Coccidia (*Choleoeimeria pogonae, Isospora amphiboluri*, *Eimeria* spp.) are commonly found in the feces of even normal, healthy Beardies - this is referred to as Coccidiasis. The mere presence of *Coccidia* spp. in a fecal sample of a healthy animal is not justification for treatment. Coccidia with concurrent morbidity is referred to as coccidiosis. Sub-adults seem to be more susceptible to coccidiosis as are animals subjected to immunosuppressive conditions (poor husbandry, co-morbidities).

Clinical signs are non-specific such as anorexia, wasting, failure to thrive and ultimately death. Treatment is generally well tolerated and effective with Ponazuril, 30 mg/g, PO q 24h for 3 treatments, and repeated in 2 weeks.

Microsporidiosis

Microsporidia, originally thought to be a protozoan, has been reclassified as a primitive fungus. In Beardies specifically, the microsporidian *Encephalitozoon pogonae* has been associated with several colony outbreaks, including animals housed communally in pet stores. This pathogen is frequently seen in association with either or both Atadenovirus or Coccidiosis (*I. amphiboluri*).

Similar to other pathogens, Dragons affected with Microsporidia show typical "sick lizard" symptoms. The organism can affect multiple tissues, generally resulting in widespread organ failure. Diagnosis can be made via PCR testing. A gram stain of oral secretions or fresh feces may reveal the fungal organism.

Prognosis is grave.

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Mycotic Dermatitis

Bearded dragons are seemingly exquisitely sensitive to fungal infections, specifically with a fungus known as the Chrysosporium anamorph of Nannizziopsis vriesii (CANV). The patients present with sometimes deep ulcerations and yellow discoloration of the skin (hence the common name - Yellow Skin Disease). This is highly contagious to other Dragons and can cross over to other reptile species. CANV is often fatal due to its destructive nature.

Treatment involves aggressive therapy with debridement of lesions, systemic voriconazole (10 mg/kg, PO q 24h) and topical antifungals. Treatment may be prolonged and severe scarring can be expected in some cases.

Cephalic Aneurysms

Although most commonly associated with the head, aneurysms have been reported in tissues throughout the body in Beardies. In the head lesions usually arise from the internal carotid or from a portion of the aorta when reported elsewhere. Patients present with large, fluid filled masses on the side of the head, along the spine or an extremity.

The cause is not known. There have been no reported successful medical treatments, but there have been a few isolated cases where surgical intervention has prolonged the patient's life. Depending on the location of the aneurysm the prognosis is guarded to grave.

Conclusion

Bearded Dragons, with their prehistoric appearance, engaging personalities and ease of care will certainly be a popular reptile pet for years to come. Veterinarians choosing to treat exotic pets are encouraged to learn about these fascinating animals.

References available on request.

The Vet at Noah's Ark -
Stories of Survival from an Inner-City Animal Hospital

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People have always had a love for animals. Stories about the power and magic of the Human-Animal bond have captivated audiences since the beginning of time.

Back in the early 1970's British veterinarian James Herriot penned a collection of books about his career. "All Creatures Great and Small" was the first in the highly successful series. The stories were so popular that they have been made into two different television series, still airing on PBS today.

Dr. Doug Mader, local Keys' veterinarian and long time Key West Citizen columnist, has just released his first book for the mainstream audience: "*The Vet at Noah's Ark - Stories of Survival from an Inner-City Animal Hospital*." Whereas Dr. Herriot's stories emanated from the beautiful, picturesque rolling hills of Yorkshire, England, Dr. Mader's book emerges from the urban jungle and his days practicing veterinary medicine in the Los Angeles area, replete with concrete, gangs, graffiti, drugs, hookers and drive-bys.

Set amidst the backdrop of the social unrest surrounding the racially charged trial of the four police officers accused of beating Rodney King, the story is told over the course of one year and follows Dr. Mader as he navigates the trials of running a busy animal hospital while pursuing his life's mission of preserving the all important Human-Animal bond.

Dr. Mader has set a personal goal of becoming a Board Certified Veterinary Specialist - an arduous task that takes years of preparation and culminates with an extremely difficult two day examination. Somehow he manages to find time to study all while trying to balance the conflicts inherent in a bustling hospital - an absentee partner, capricious associates, love struck employees, neophyte, sometimes challenging young veterinary students and many crazy clients with their bizarre pets – including Piz, the drug dealing guinea Pig owner, Do Do the Emu, Mikey the Monkey, Fore the three-legged Fox, a potentially rabid wolf that exposes all of the employees and so much more.

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During the Rodney King Riots the staff stood armed watch on top of the building guarding the hospital. Even Lisa, the five feet, one inch receptionist, kept a loaded Glock in her purse.

One of the main characters in the book is Wok, Dr. Mader's Chow Chow dog. Wok is the Doc's best friend, confidant and personal bodyguard. Dr. Mader's most personal inner thoughts and feelings are revealed during his frequent nocturnal "Wok walks" through the dangerous streets and parks of the urban jungle.

Readers get to ride shotgun with Dr. Mader as he juggles life and work as an inner-city animal doctor. The author does an excellent job matching humor with heartbreak through his many anecdotes. Set over the course of one year, the storyline follows the lives of Dr. Mader's staff, which he considers his family, and several clients and patients - many of which are recurring throughout the book. Through his rich character development the reader gets to know and fall in love with, or in some cases, hate, some of the humans that he deals with on a daily basis.

Being a story based on actual events, there are scenes that contain harsh language and graphic descriptions, especially that of cruelty between humans and animals, and, other humans.

James Herriot set high standards with his incredible storytelling prowess a half century ago. For the first time in over 50 years, American veterinarian Dr. Doug Mader has matched the task. Although technically a memoir, the book reads more like a well written, fast paced medical drama suited for both animal lovers and anyone that likes a good read.

The Vet from Noah's Ark is gritty and honest. It will pull at the reader's heartstrings. There are plenty of stories about all sorts of animals, but be warned, not all have happy endings. Prepare to shed a tear or two, but most of all, be ready to celebrate the magic of the Human-Animal bond.

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