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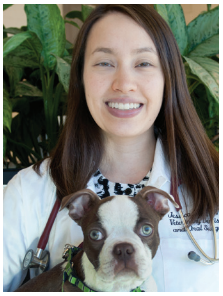
VETERINARY REFERRAL NEWS FROM ANGELL ANIMAL MEDICAL CENTER



DENTISTRY

Cone Beam Computed Tomography (CBCT): Ancillary Diagnostic Imaging in Veterinary Dentistry Patients

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Cone beam computed tomography (CBCT) is a relatively newer imaging modality to veterinary dentistry. Although this method has been available and highly used in human dentistry for many years, it was first evaluated for veterinary purposes only a decade ago. Since then, advancements have been made to make it a successful method for evaluating dental and maxillofacial anatomy. CBCT permits a three-dimensional evaluation of structures and multi-planar views. It has become extremely useful for assessing endodontic disease, maxillofacial trauma, and oncologic disease.

CBCT varies from traditional conventional computed tomography (CT) in a number of ways that are well-suited for veterinary dentistry. Whereas in conventional CT, when a fan-shaped X-ray beam is emitted, and the patient needs to be moved through the gantry, with CBCT, the X-rays are cone-shaped, and the machine rotates around a stationary patient. The X-ray source in CBCT comes from a flat source, which is opposite of the sensor. These characteristics allow the CBCT to operate with only one pass around the patient, and the patient receives very low radiation.

(CONTINUED ON PAGE 2)

NEUROLOGY

Cannabidiol (CBD) in Canine Epilepsy

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Idiopathic epilepsy is the most common neurologic condition in dogs. Despite the countless advancements in veterinary neurology, from neuroimaging to surgical procedures, treatment options for refractory epileptics remain limited. Cannabis-based therapies have gained considerable recognition over the last decade due to their use in human medicine to treat and manage various conditions, including epilepsy. Until recently, little was known about the safety, efficacy, pharmacokinetics, and side effects of cannabis in dogs. With the emergence of new clinical studies, practitioners can feel more confident in discussions with clients about the potential use of cannabis-based therapies in veterinary patients.

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INSIDE: REFERRAL CONTACT INFO ON A REMOVABLE POSTCARD

DENTISTRY

Cone Beam Computed Tomography (CBCT)

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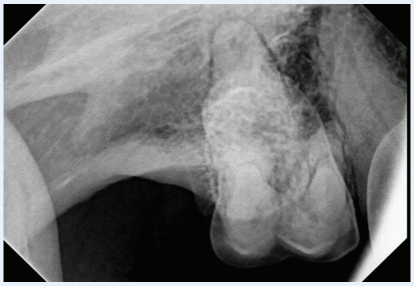
Figure 1

Dental radiograph of the right maxillary first molar (109) using standard bisecting angle technique.



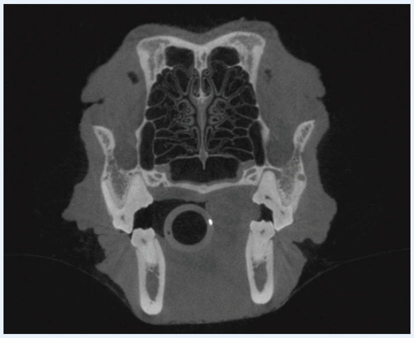
The design of most CBCT machines is smaller and allows it to be transported or moved for convenience.

Imaging of the maxillofacial region has previously been accomplished by dental radiographs, skull radiographs, and conventional/helical computed tomography. Each of these methods has its advantages and disadvantages.

Dental radiography has been the standard of care since it is easily available, several options exist (DR, CR, a variety of software), has a reasonable price point, and provides extremely valuable clinical information. It evaluates the dentition and the bone surrounding the teeth, allowing the user to evaluate both periodontal and endodontic aspects. The X-rays are focused on a small area, and there is a relatively low overlap of other structures. Interpretation can be more challenging in brachycephalic patients due to their anatomy, with crowding and rotation of teeth expected. Dental radiograph use for evaluating maxillofacial structures as a whole is limited.

Figure 2

Same patient as Figure 1. Axial image obtained from CBCT at the level of the maxillary first molars. The patient's right side is on the right side of the image. Note the periapical lucency associated with the mesiobuccal and palatal roots of the right maxillary first molar (109), which are not easily identified on the previous radiograph.



Skull radiographs will give a more global view to the user when looking at maxillofacial structures and evaluating for maxillofacial trauma (i.e., fractures). The downsides are that diagnostic skull radiographs can be challenging to obtain without an experienced user performing positioning (appropriate marking necessary, right and left obliques, dorsal-ventral, and rostrocaudal views all necessary), and interpretation can be challenging. The difficulty in interpretation arises from the superimposition and overlapping of structures, which can make them of limited use. For quality images, patients need to be sedated to obtain skull radiographs.

Magnetic resonance imaging (MRI) can be useful when evaluating soft tissue structures of the head; however, its ability to assess dental or maxillofacial bone is inadequate.

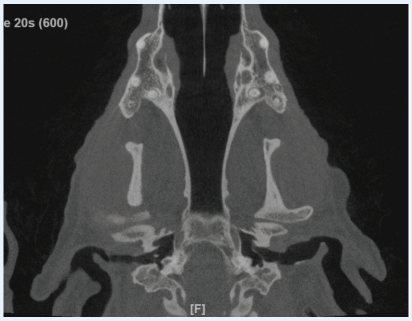
As previously mentioned, **standard computed tomography** provides 3-D imaging of the maxillofacial region and is commonly available at multi-specialty hospitals. The generator rotates around the patient as the patient moves through the gantry. The captured images overlap slightly, and computer software transforms the data into 3-D images. CT eliminates the issue of superimposition when evaluating the maxillofacial structures. It can be used to evaluate hard tissue (teeth and bone) and soft tissue. Additionally, with the use of contrast, certain features can be enhanced (areas of inflammation or increased vascularity). The price of these units, the need for an experienced technician to perform scans, dedicated floor space, and requirements for appropriate radiation safety make this modality impractical for general use.

Similar to standard CT, CBCT eliminates the problem of superimposition of structures, creates a 3-D reconstruction of the area of interest, and allows evaluation of dentition and bone. CBCT has the capability to provide increased detail of the dentoalveolar structures due to thinner slices and better resolution. Compared to standard CT, which will obtain a slice (image) every 1 to 3 mm, CBCT slice thickness is 0.1 to 0.4 mm. This is a great advantage when evaluating dental structures. Previous studies have indicated that CBCT was superior in image quality compared to standard CT when assessing enamel, dentin, pulp cavity, periodontal ligament space, lamina dura, and trabecular bone.

Clinically speaking, the greatest advantage of adding CBCT in veterinary dentistry patients comes from the ability to see anatomy in a 3-D nature. Compared to our two-dimensional radiographs, CBCT eliminates missing or misinterpreting pathology since overlapping structures are eliminated. The sensitivity of CBCT to demineralization of bone permits a periapical

Figure 3

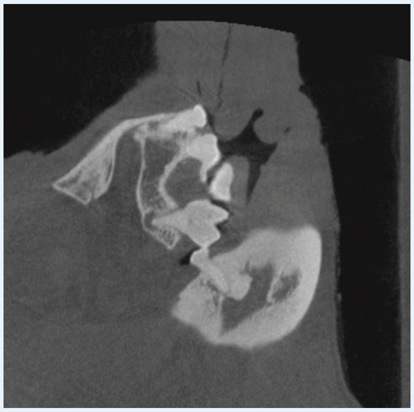
Same patient as Figures 1 and 2. Coronal view obtained from CBCT at the apical region of the maxillary fourth premolars and first molars. The patient's right side is on the right side of the image. The widened periodontal ligament space and periapical lucencies around the mesiobuccal, distobuccal, and palatal roots of the right maxillary first molar (109) can be identified. The proximity of the mesiobuccal root of 109 to the distal root of the maxillary fourth premolar (108) can also be appreciated.



lesion to be detected sooner than visible changes can be identified on a dental radiograph, therefore allowing endodontic disease to be picked up sooner. The risk for complications from extractions is also minimized when using CBCT as it allows more information on the positioning of roots to neighboring vital structures (e.g., mandibular canal, infraorbital canal, nasal cavity, or sinuses). Surgical approach and expectations on what may be encountered can also allow a better-informed clinician, particularly if there is a structural abnormality to a root, such as dilaceration to the root end.

Figure 4

Same patient as Figures 1, 2, and 3. Sagittal view from CBCT images at the level of the palatal root of the right maxillary first molar (109). A periapical lucency is clearly defined around the root apex, indicating endodontic disease, leading to the decision for surgical extraction of the tooth.



DENTISTRY

Cone Beam Computed Tomography (CBCT)

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Dental radiographs will likely continue to remain the standard of care for dentistry, with CBCT as an ancillary technique used at the specialist level. Specific indications for CBCT include evaluating maxillofacial trauma (i.e., jaw fractures), temporomandibular joint disease, brachycephalic patients (with crowding and rotation of teeth), cystic lesions (i.e., dentigerous cyst), palatal defects, or bony tumor involvement. In the future, manufacturers will likely work on different software versions with algorithms to better evaluate soft tissue.

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Cannabidiol (CBD) in Canine Epilepsy

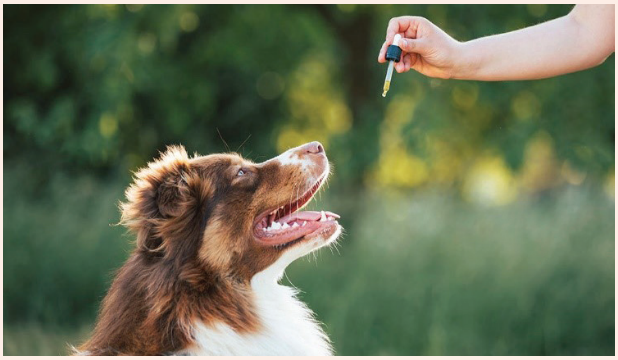
CONTINUED FROM PAGE 1

Cannabis sativa is an herbaceous plant native to central Asia. The plant contains over 100 cannabinoids, including tetrahydrocannabinol (THC) and cannabidiol (CBD). Cannabinoids target cell membrane receptors and alter membrane potential and neurotransmitter release, which can increase seizure threshold. Some cannabinoids also target endogenous cannabinoid receptors present in the body, namely CB1 and CB2, and can affect the release of excitatory and inhibitory neurotransmitters. THC, a cannabinoid well-known for its psychoactive properties, has toxic effects on pets and is not recommended for medical treatment in pets. In contrast, CBD is non-psychotropic and has demonstrated neuroprotective, anticonvulsant, and anxiolytic properties, among others, in human medicine. Therefore, CBD has become a focus for continued studies over the last five years about its application to manage canine epilepsy.

CBD is reported to have low bioavailability in humans and dogs and also goes through a high first-past effect in the liver. To address these challenges, CBD is often administered in oil-based formulations. The liver metabolizes CBD and inhibits several cytochrome p450 isoenzymes raising the concern for potential drug interactions. McGrath et al. (2018) initially reported on adverse effects associated with CBD in healthy dogs. In their study, 30 healthy Beagles were placed in three groups and administered CBD in either an oral capsule, transdermal cream, or oral oil suspension at doses of 10 to 20 mg/kg/day over a six-week period. All dogs in the study developed diarrhea, which was resolved with a course of metronidazole therapy. Elevations in alkaline phosphatase enzyme (ALP) were noted in over a 1/3 of the dogs with no evidence of hepatotoxicity based on normal fasting and post-prandial bile acids. The study concluded that CBD was well tolerated in dogs. A follow-up

study by McGrath et al. (2019) evaluated the effect of CBD in addition to conventional antiepileptic treatments in refractory epileptic canine patients. In this randomized, controlled clinical trial, 26 client-owned dogs with refractory epilepsy were assigned to either a treatment group or placebo group for 12 weeks. The treatment group received a CBD oil suspension dosed at 2.5 mg/kg twice daily for 12 weeks. Sixteen dogs completed the study. A significant reduction of 33% in monthly seizures was noted in the CBD group, and an increase in ALP. It was also noted that there was a negative correlation between the change in seizure frequency and plasma CBD concentration. This is worth mentioning as it may indicate that higher doses of CBD are needed in canine patients than in humans. Bile acids were not measured in this study; however, serum Phenobarbital and Bromide levels were unchanged in the patients.

More recently, Garcia et al. (2022) evaluated the use of a CBD/CBDA hemp extract in refractory epileptic canine patients. In the six-month randomized double-blinded cross-over design study, 14 dogs either received the CBD/CBDA hemp extract or placebo for three months and then switched over with no washout period. The dose administered in the treatment group was 2 mg/kg twice daily. All dogs in the study were on three or more antiepileptic drugs with no recent adjustments in dosing. Notably, six of the 14 dogs in the study showed a >50% reduction in seizure frequency on the CBD/CBDA hemp extract. ALP was again noted to be elevated; however, no differences were observed in serum Zonisamide, Phenobarbital, or Bromide concentrations, suggesting that CBD does not affect the metabolism of antiepileptic drugs. Mild ataxia and somnolence were noted in four dogs and three dogs, respectively, in the treatment group though this was not significantly different from the placebo group.



Based on the studies above, CBD appears to have a clear antiepileptic effect and is a reasonable and safe treatment option in conjunction with conventional antiepileptic medications for managing idiopathic epilepsy, particularly in refractory cases. Additional studies are warranted to evaluate optimal dosing further and assess efficacy in patients with various types of seizure disorders, but the current literature is promising. Obtaining CBD can be challenging as most formulations are only available online for purchase, and the quality of the product can vary considerably, so clients should use caution and seek out reputable brands.

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Emergency & Critical Care Service at Angell West; Urgent Care Available by Appointment

The Emergency & Critical Care service at the MSPCA-Angell West (Waltham, MA) is available 24/7 for clients whose pets need immediate medical care for life-threatening trauma or disease.

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*For more information, please visit **angell.org/emergency**.*

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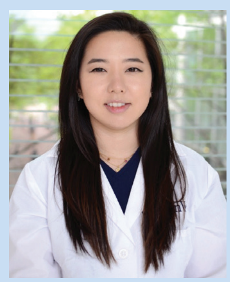

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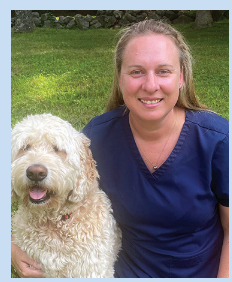

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EMERGENCY & CRITICAL CARE

Canine Hypoglycemia

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Hypoglycemia is a consequence of many serious disease processes, and without treatment to correct this and the underlying cause, it is commonly fatal. The body has multiple counter-regulatory systems to regulate blood glucose levels to avoid hyper and hypoglycemia. Secretion of insulin in response to hyperglycemia and glucagon and epinephrine in response to hypoglycemia all work to maintain normoglycemia. Many serious systemic illnesses can interfere with glucose hemostasis and lead to life-threatening hypoglycemia. Hypoglycemia deprives cells of glucose necessary for cellular metabolism and can rapidly result in severe clinical signs. Transportation of glucose across the blood-brain barrier relies on a diffusion gradient with arterial blood, and hypoglycemia can result in neuroglycopenia leading to altered mentation and seizures.[1]

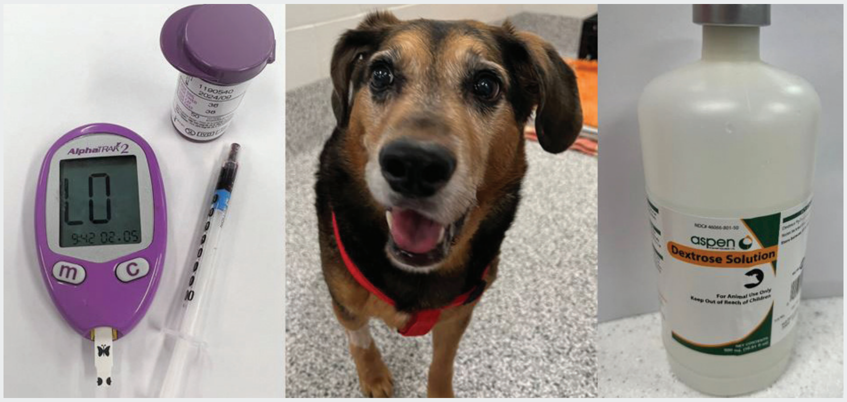
Hypoglycemia in patients can be seen as a result of multiple severe systemic illnesses, including sepsis, hepatic failure, neoplasia, malnutrition, severe exertion or prolonged seizure activity, and other less common causes. Combining exam findings and basic diagnostics can usually provide a definitive or highly suspected cause for hypoglycemia. Complete blood cell counts may show a severe increase or decrease in white blood cell counts associated with infection and possible sepsis. Severe elevation in transaminases (ALT, AST) can suggest an acute hepatic injury or other changes suggestive of a more chronic hepatic dysfunction (elevated bilirubin, reduced BUN, and cholesterol). Imaging findings may include evidence of aspiration pneumonia or other signs of infection, including peritoneal-free fluid/gas due to GI perforation. Changes in hepatic size on radiographs can suggest a chronic hepatopathy (reduced hepatic size) or infiltrative disease (severe hepatic enlargement).

In less common situations, hypoglycemia can be an unexpected finding in a patient without overt evidence of these conditions. In these seemingly "healthy" patients, veterinarians pursue a different diagnostic route looking for illness that affect glucose utilization or production within the body. Accurate diagnosis and treatment of these critical cases are essential and can result in a good long-term prognosis for these patients.

Xylitol is a 5-carbon sugar alcohol used as an artificial sweetener commonly found in gums and other low-carbohydrate products. In canine patients, xylitol results in the inappropriate release of insulin, leading to severe hypoglycemia and altered mentation and seizures.[2] Treatment is supportive in nature with supplemental dextrose and blood sugar monitoring until signs have resolved and supplementation can be discontinued. Diagnosis is typically based on clinical history and recent known exposure to xylitol-containing products. Mild elevations in transaminases can be seen in many symptomatic cases, and less commonly, severe hepatic injury and failure can occur. Treatment typically carries a good prognosis in patients that do not develop hepatic failure.

Canine Addison's disease is commonly considered in patients that present with azotemia and classic electrolyte changes, including hyponatremia and hyperkalemia, which result from a deficiency of the mineralocorticoid aldosterone. A subset of Addisonian patients (~10%) are only deficient in glucocorticoids and lack these electrolyte derangements.[3] Lack of glucocorticoids impairs gluconeogenesis and can result in hypoglycemia in a small number of patients (22%), leading to obtundation or seizures.[3] Treatment includes supplementation of glucose with injectable dextrose and replacement glucocorticoid therapy. A low baseline cortisol can suggest this condition, and a diagnosis is confirmed with a lack of response on ACTH stimulation testing. This condition also carries a good long-term prognosis with appropriate supplementation of steroid hormones.

Insulinoma is the most common pancreatic neuroendocrine tumor and retains the ability to secrete insulin. Clinical signs associated with it are commonly related to the effects of hypoglycemia leading to neuroglycopenia. Acute treatment of hypoglycemia secondary to insulinoma includes careful glucose supplementation, as further insulin secretion can lead to rebound hypoglycemia with treatment.[4] Parenteral administration of steroids can also be beneficial for its effects in inducing insulin resistance. Administration of injectable glucagon can also be used in cases refractory to dextrose and steroid administration and commonly results in the resolution of hypoglycemia.[5,6] This short-term treatment option can be useful in stabilizing a patient to allow additional diagnostics and more definitive treatments. A diagnosis of an insulinoma is made by an insulin-glucose ratio showing an inappropriately elevated insulin level with concurrent hypoglycemia. If a mass can be identified and excised via surgery, up to 80% of patients can have a resolution of hypoglycemia and a prolonged median survival (746 days).[7]



Canine Hypoglycemia

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Familial and Congenital Renal Diseases of Dogs

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Several types of familial and congenital renal diseases are reported in dogs. Diseases categories include renal dysplasia, glomerulopathies, polycystic kidney disease, and with tubular defects. Patients can initially present anywhere from a few weeks to several years old. Clinical signs may be absent or mild at initial evaluation, or changes in lab work may be found incidentally. Otherwise, clinical signs are often related to kidney dysfunction, including polyuria, polydipsia, decreased appetite, vomiting, and decreased body condition. The disease progression rate is often variable, though with some specific diseases noted below, the progression may be very quick and result in a significantly shortened life span. Diagnosis is often made based on age when azotemia is first noted, imaging findings, and if there is a known breed association. However, it is important to remember that many cases likely go unreported so all breed associations are likely unknown. Ultrasound may be unremarkable, but changes that may be noted include small irregular kidneys (uni or bilateral), decreased corticomedullary definition, hyperechoic speckling in the renal medulla, and a generalized increase in medullary echogenicity. Histopathology, including sometimes electron microscopy, is needed for a definitive diagnosis of many of the below forms of renal disease. However, this is often not pursued as management for most patients is the same as for patients who develop chronic kidney disease later in life.

Renal dysplasia (RD) is a hereditary disease characterized by abnormal differentiation and disorganized development of renal parenchyma. In most cases, the exact mode of inheritance or genetic mutation is unknown. A wedge biopsy is necessary as a minimum of 100 glomeruli must be assessed for a definitive diagnosis.[1] A recent study[2] evaluated the potential role of cyclooxygenase-2 (COX-2) in RD. Although COX-2 is typically associated with pathologic events, studies cited in this article suggest that COX-2 has an important role in in-utero kidney development. In this study, mutant alleles of COX-2 were found to have a 100% correlation with clinical cases of RD.[2] Breeds with the highest incidence of RD had the highest frequency of mutant alleles. Immature or fetal glomeruli remain present in the kidney past six months of age, and the higher the percentage of fetal glomeruli, the more severe changes in other kidney tissue.[3] Over time, secondary degenerative

and inflammatory changes occur. Renal dysplasia has been best characterized in the Shih Tzu and Lhasa apsos.[3,4,5] Still, it is reported in many other breeds of dogs, including but not limited to Golden Retrievers,[6] Dutch Kooiker dogs,[7] Boxers,[8] and Beagles.[9] Renal dysplasia has been reported concurrently with other urogenital abnormalities, including unilateral renal agenesis[10] and ureteral ectopia.[11]

Amyloidosis is characterized by the extracellular deposition of insoluble fibrillary proteins with a specific beta-pleated sheet conformation. The hereditary form is caused by abnormal genes encoding variant proteins whose structures make them amyloidogenic. Familial amyloidosis has been reported in the Chinese Shar-Pei (CSP),[12] Beagles,[13] and English Foxhounds.[14] Familial Chinese Shar-Pei fever, with recurrent fevers and swollen hocks, predisposes to secondary (reactive) amyloidosis. Unlike most other breeds affected by amyloid, in CSPs, the lesions are primarily medullary and often have deposition in other organs. In non-CSPs, lesions are more commonly glomerular in location, and while both CSPs and non-CSPs have increased urine: protein to creatinine ratios, the presence of hypoalbuminemia and nephrotic syndrome is higher in non-CSP breeds (JVIM Retro shar/nonshar). Age at presentation is often younger (median six years) for CSPs, while non-CSP breeds can present later in life.[15]

Hereditary nephritis results from a genetic mutation leading to the abnormal formation of type IV collagen. Type IV collagen consists of heterotrimers of six possible peptide α- chains 1 to 6. Mutations cause improperly formed chains to be unable to interact with other chains. The faulty interaction leads to glomerular basement membrane splitting and thickening. The ultrastructural changes in the basement membrane alter glomerular permeability and selectivity, leading to the loss of larger molecules such as albumin. As with other causes of renal protein loss, the excess protein can damage renal tubular cells, cause mesangial proliferation, and obstruct tubules with protein casts.[16] X-linked hereditary nephritis of Samoyeds has a nucleotide substitution in the COL4A5 gene causing abnormal alpha-5 chains. Proteinuria is the first indicator that can occur as early as three months of age

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in males, with progression to severe azotemia in one year. In females, the rate of progression is much slower, with azotemia apparent after a few years.[17] English Cocker Spaniels have an autosomal recessive form of the disease, and both sexes are affected equally. Again proteinuria is detected at a few months of age, with azotemia developing in one to two years. An autosomal dominant mutation has been described in Bull Terriers and Dalmatian dogs, but the genetic mutation has not been fully characterized. Age of onset is variable from a few months of age up til seven to eight months.[18] Electron microscopy is often needed to make a diagnosis for this class of renal disease.

Podocytopathies are another form of hereditary nephritis. In the normal slit diaphragm, numerous molecules interact and connect to the cytoskeleton of the podocyte foot processes. The interaction enables three-dimensional changes in the shape and size of the slit diaphragm but, when damaged, leads to protein loss and focal segmental glomerulosclerosis. A genetically linked podocytopathy is suspected in some breeds, including the soft-coated Wheaton Terrier[18,19] and Airedale Terrier.[20] Variant alleles (NPHS1 and KIRREL2) encoding the proteins of the immunoglobulin superfamily, nephrin, and Neph3/filtrin, which are part of the complex structure of the slit diaphragm have been identified in these breeds.[18] In SCWT, the age of onset tends to be later (six years), and clinical signs often involve the intestinal tract and the signs of protein-losing nephropathy.

Polycystic kidney disease (PKD), a genetic disorder characterized by bilateral renal cysts of varying size and number within the cortex and medulla, has been primarily reported in Bull Terriers,[21] Cairn Terriers,[22] and West Highland White Terriers (WHWT).[23] An autosomal dominant mode of inheritance of a genetic mutation of the polycystin-1 (PKD-1) gene has been found in Bull Terriers. In contrast, an autosomal recessive mode is suggested in the Cairn and WHWT. Decreased kidney function is noted in the first years of life in Bull Terriers, while an earlier onset (first months of life) is seen in Cairn and WHWT. Additionally, multiple cysts are noted in the latter breeds in the kidneys and liver. Though rarely reported in dogs, other cystic diseases of the kidney include medullary sponge kidney, where cysts arise in the medullary collecting ducts (Shih Tzu)[24] and glomerulocystic kidney disease, where there is a cystic dilatation of > 5% of Bowman's spaces (Belgian Malinois, Collie).[25, 26]

Congenital tubular defects are uncommon in dogs but have been reported in isolation and conjunction with other hereditary or familial renal diseases.[27] Tubular disorders include primary renal glycosuria, aminoaciduria, electrolyte disorders, proximal and distal tubular acidosis, and nephrogenic diabetes insipidus. The main feature of these diseases is the loss of various substances (glucose, water, amino acids) that typically the tubules would conserve.

Congenital Fanconi syndrome with renal dysplasia was reported in Border Terriers,[28] while the most recognized Fanconi syndrome is reported in Basenji.[29] Diagnosis in this category of diseases is typically made through alterations in the biochemistry profile, blood gas analysis, and urine amino acid profiling. Additional treatments may be needed to help support acid-base balance.

In summary, though not encountered often, there are many types of congenital and familial renal diseases in dogs. Early identification is vital for management as progression is often variable between and within each type of renal disease. Ongoing research is needed to characterize further specific genetic or hereditary links for these early-onset renal diseases.

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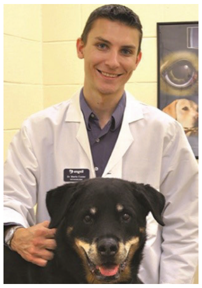
OPHTHALMOLOGY



Feline Iris Hyperpigmentation

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Iris hyperpigmentation is commonly encountered in cats, but clinical management of these cases is challenging since the pigment can represent anything from benign change (melanosis) to malignant neoplasia (feline diffuse iris melanoma, FDIM, Figure 1).

Iris melanosis is a benign increase in melanocytes on the surface of the iris. Feline diffuse iris melanoma is a malignant clonal expansion of these melanocytes in an uncontrolled and disorganized fashion. It is presumed that iris melanoma can develop from iris melanosis, but the process is very unpredictable. The terminology of "diffuse" iris melanoma may also be misleading since some melanoma can be focal on the iris surface.

The veterinary literature is relatively sparse for peer-reviewed research on the topic. A 2016 survey[1] of board-certified veterinary ophthalmologists, in which case details and photos were presented, and the ophthalmologist was asked to make a diagnosis of melanosis or melanoma, showed that even experienced clinicians have a difficult time determining the significance of iris hyperpigmentation, even when expressing confidence in their opinion. Factors that enhanced correct identification were lesion thickness, progression over time, surface area of involvement, pupillary light reflex testing, intraocular pressure, and the presence of uveitis (aqueous flare). The most challenging diagnoses are the intermediate cases lying somewhere on the spectrum between small foci and complete iris surface pigmentation.

Figure 1

» Histopathologically-confirmed feline diffuse iris melanoma, of the cat's right eye, in contrast to the normal yellow iris coloration of the left eye.

Given this caveat, Figures 2 to 4 show three hyperpigmented lesions in three cats and each was an example of iris melanosis. Key determinants of these opinions included the following:

1. The lack of raised/thickened tissue. Generally, the mitotic activity of melanoma will lead to the thickening of the layer of pigment, whereas melanosis is from an accumulation of normal melanocytes in their normal location.
2. Heterogeneity of the lesion on microscopic examination. Iris melanoma often develops a more homogeneous "velvet-like" appearance due to the clonal expansion of pigmented cells with little structural detail of the normal iris remaining.
3. Lighter pigment due to a lower melanin component in the pigmented cells.
4. Normal iris excursions during pupillary light reflexes (PLR). Iris melanoma may invade deeper into the iris stroma than iris melanosis, affecting the pupillary muscles.
5. Normal intraocular pressure, absence of any uveitis or glaucoma.
6. Absence of pigment dispersion elsewhere within the anterior chamber (e.g., pigment on the lens capsule, corneal endothelium, or free-floating in the aqueous humor).

Nevertheless, any hyperpigmented iris lesion should be monitored with time. The owners should be educated that the "diagnosis" is often, at best, a clinical suspicion and that growth of the lesion or conversion to iris melanoma may occur at any time.

Figure 2

» Focal hyperpigmented lesion in the lateral iris of the right eye of a cat. This may be described as an iris freckle.

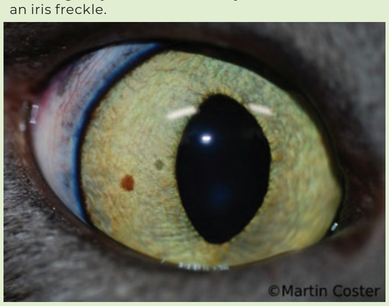


Figure 3

» Focal hyperpigmented lesion in the inferior iris of the left eye of a cat. A larger freckle may be described as a nevus.

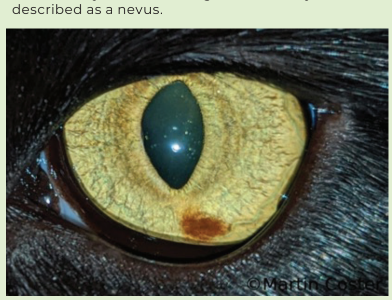
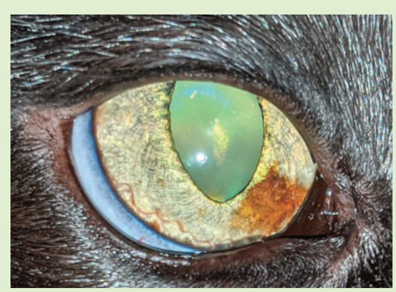


Figure 4

» Focal hyperpigmented lesion in the inferior-medial iris of the right eye of a cat.



Feline Iris Hyperpigmentation

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Figure 5

› Relatively generalized iris hyperpigmentation of the right eye of a cat. Although this is clinically suspected to be a variant of iris melanosis, histopathology is needed to rule out feline diffuse iris melanoma.

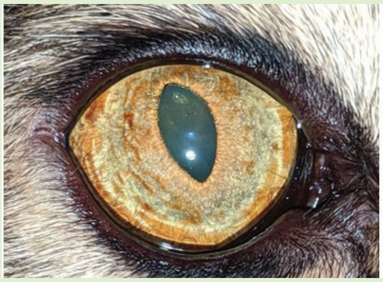
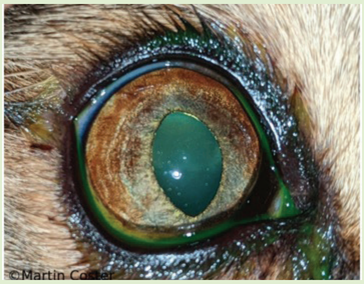


Figure 6

› Relatively generalized iris hyperpigmentation of the right eye of a cat. It is impossible to determine if this is iris melanosis or feline diffuse iris melanoma without an accurate biopsy for histopathology.



Iris biopsy[2] may be offered by a veterinary ophthalmologist to provide a more precise diagnosis. Under general anesthesia, two small limbal incisions are made, the anterior chamber is filled with a viscoelastic agent to maintain its form, and the iris lesion is grasped with forceps and biopsied with iris scissors. The viscoelastic agent is then removed, and the limbal incisions are sutured. Complications can include hemorrhage, uveitis, pupil abnormalities, and corneal ulceration. Importantly, there is no guarantee that the lesion will be appropriately sampled, with melanoma being possibly misidentified as melanosis or not identified at all. For more scattered or diffuse lesions (e.g., Figure 5), the area sampled will be critical to achieving the correct diagnosis.

Figure 7

› Feline diffuse iris melanoma, confirmed with histopathology, in the left eye of a cat. The hazy area is a vascularized corneal ulcer or associated scar tissue.

With advancing age, iris melanosis may become more diffuse, often appearing in a "tiger-stripe" formation (Figure 5). Possibly, pupillary excursions provide pressure that aligns the melanocytes. These eyes should be closely monitored for darker or raised areas of pigment developing or any interruption of the pupillary excursions during the PLR.

Further darkening and coalescing of the hyperpigmented areas may lead to an iris like that of Figure 6. At this point, knowing a definitive diagnosis based on clinical examination alone is impossible. While much of the pigment may remain flat, lighter in coloration, and heterogeneously dispersed, there may be darker, thicker, more homogeneous areas consistent with focal melanoma in a background of melanosis. The presence of uveitis, glaucoma, pigment dispersion, and/or disturbance of PLR would be more indicative of FDIM.

Figure 7 shows further progression of iris hyperpigmentation, with an extremely high index of suspicion for FDIM. The pigmented areas are darker, with some raised with a homogeneous velvety appearance; this case was confirmed as FDIM with histopathology following enucleation.

Figure 8 shows profound thickening of the iris pigment, with a more homogeneous velvety appearance, and distortion of the pupillary margin, a definitive FDIM.

If FDIM is suspected, a full metastasis screening is recommended, including bloodwork, thoracic radiographs or thoracic computed tomography (CT), and abdominal ultrasound or CT. Sites of melanoma metastasis can include but are not limited to local lymph nodes, lungs, liver, spleen, kidneys, and rarely the contralateral eye. However, it must be cautioned that early metastatic lesions may be missed even with extensive and advanced diagnostics.

A landmark 2002 paper examined survival times in enucleated cats with confirmed FDIM compared to control cats, concluding that *"early enucleation is important to avoid premature death, presumed to be due to cancer metastasis in cats with diffuse iris melanoma."*[3] Importantly, cats with glaucoma secondary to FDIM appeared to have a lower survival rate, of 21% (four of 19) compared with 73% (11 of 15) of cats without glaucoma (although the difference only approached statistical significance). This was likely because glaucoma

Figure 8

› Feline diffuse iris melanoma, confirmed with histopathology, in the right eye of a cat.

develops secondary to a more extensive invasion of the melanoma into the ocular tissues and associated uveitis/inflammation from the destructive tumor. However, a more recent 2016 study[4] did not show an increased risk of metastasis in cats with glaucoma, suggesting both that metastasis can occur before glaucoma develops and that glaucoma itself does not increase the metastasis rate. This study still recommended the enucleation of glaucomatous eyes with FDIM.

If hyperpigmented lesions are detected early, close monitoring should be initiated every two to three months, including photodocumentation and intraocular pressure. Transcorneal diode laser treatment has been described[5] as a way to limit the progression and spread of focal lesions and even to treat diffuse iris hyperpigmentation (whether melanosis or melanoma) to halt the progression to or of melanoma. The cat is anesthetized in this procedure, and diode laser energy is applied through the cornea until the pigmented regions shrink by 50% or more. Although distortion of the pupillary margin and associated post-operative light sensitivity is a likely outcome, corneal ulceration, hyphema, and/or uveitis may occur as secondary complications, the procedure is generally considered safe. Results are variable, and it is a matter of continued debate whether pigment progression is halted or only temporarily slowed (Figures 9 and 10).

Possibly the biggest quandary in managing feline iris hyperpigmentation is deciding when to enucleate a progressively pigmenting eye. Factors such as the cat's age, comorbidities, the health of the other eye, and the owner's risk tolerance must be weighed. The opinions of veterinary ophthalmologists vary widely, with reports of seeing metastatic disease and orbital melanoma ("localized recurrence") developing several years following enucleation. For this reason, veterinarians suggest laser treatment for small progressive lesions and early enucleation for more generalized progressive disease.

Feline Iris Hyperpigmentation

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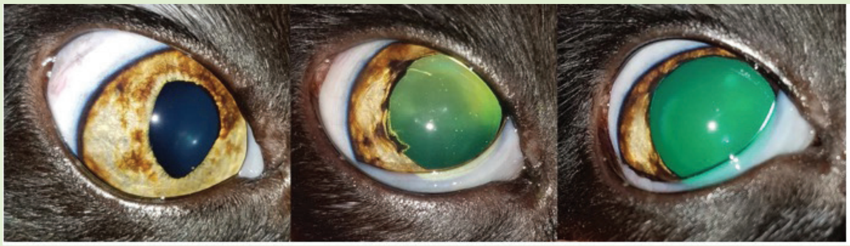
Figure 9

» Iris hyperpigmentation in the right eye of a cat before lasering (left), and the appearance 11 days (middle) and four months (right) following transcorneal diode laser. See Figure 10 for further follow-up.

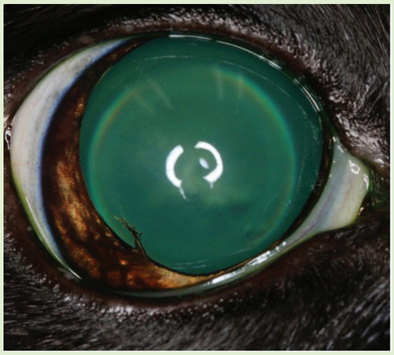


Once, and only once, the primary disease has been removed via enucleation and a diagnosis of FDIM confirmed, the owner should be referred to an oncologist for a melanoma vaccine series. The melanoma vaccine, Oncept,[6] is a USDA-licensed therapeutic vaccine proven to extend the lives of *dogs* treated for *oral* melanoma. Its use in cats for follow-up after iris melanoma surgery is considered off-label; it is not licensed nor formally approved for use in this species for this disease.

In one study, published in 2015 in the *Journal of Feline Medicine and Surgery*,[7] studied 24 cats with malignant melanoma of various types (only four with ocular or periocular melanoma) that were administered the vaccine. It was concluded that the canine melanoma vaccine can be safely administered to cats with minimal risk of adverse effects. Seven of the 24 cats experienced a mild adverse effect of the vaccine (11% of the total number of 114 vaccinations given), which included pain on vaccine administration, brief muscle irritation, transient inappetence, depression, nausea, and a mild increase in pigmentation at the injection site. Unfortunately, 14 of the 24 cats went on to succumb to melanoma. The vaccine's efficacy could not be assessed in this paper, and a third of the cats already had known metastasis, which is a different population from those typically enucleated for FDIM. Given that the vaccine is safe and may prevent the development of metastatic melanoma or delay its onset, some cat owners choose to complete the vaccination series and return for boosters.

Figure 10

» A three-and-a-half-year follow-up of the eye in Figure 9 shows the progression of iris hyperpigmentation (and focal posterior synechia from prior laser therapy). Enucleation confirmed feline diffuse iris melanoma. The cat was staged and melanoma was not found elsewhere. It is unknown whether the initial laser procedure slowed lesion progression or lowered metastasis risk. Photo courtesy of Tanja Nuhsbaum DACVO.



Author's Disclaimer

Given the relative paucity of peer-reviewed literature and ongoing debate in the veterinary ophthalmology profession about best practices in diagnosing and managing feline iris hyperpigmentation, many of the statements in this article are derived from the author's own clinical experience.

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Radiographic Appearance of Common GI Foreign Bodies in Dogs and Cats

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Vomiting and anorexia are common clinical presenting complaints in dogs and cats. While recognizing radiographic signs of mechanical obstruction of the intestines is an important skill (see https://www.mspca.org/angell_services/identifying-mechanical-obstruction-on-radiographs/), it can also be important to be able to recognize characteristics of identifiable foreign bodies on plain radiographs. These foreign bodies can often be identified even without concurrent obstruction, and monitoring with serial radiographic studies can either demonstrate positive confirmation of obstruction or confirm passage of the foreign body into the colon. This article provides examples of radiographically detectable foreign bodies in dogs and cats.

Rubber

Rubber objects are usually radiopaque, often of a mineral opacity if they are large enough pieces. This can be useful when there is known or suspected ingestion of specific rubber foreign material such as hair ties or tennis balls. Radiographs can be a very simple yes/no test in these scenarios, as the rubber material should be reliably visible in the abdomen if it is present. Rubber balls are often hollow and may appear as complete or semi-collapsed mineral opaque circles with gas-filled centers (Figure 1, red and green arrows). Tennis balls are typically chewed into fragments before swallowing and will often appear as curvilinear mineral objects, often with jagged edges (Figure 1, yellow arrows).

Figure 1

» Collapsed (red arrows), intact (green arrows), and fragmented (yellow arrows) rubber ball foreign bodies in three different dogs.

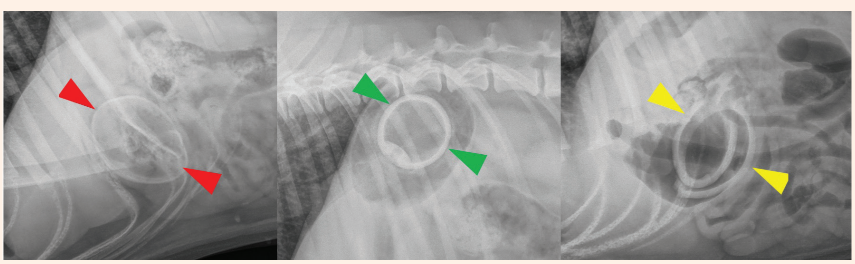
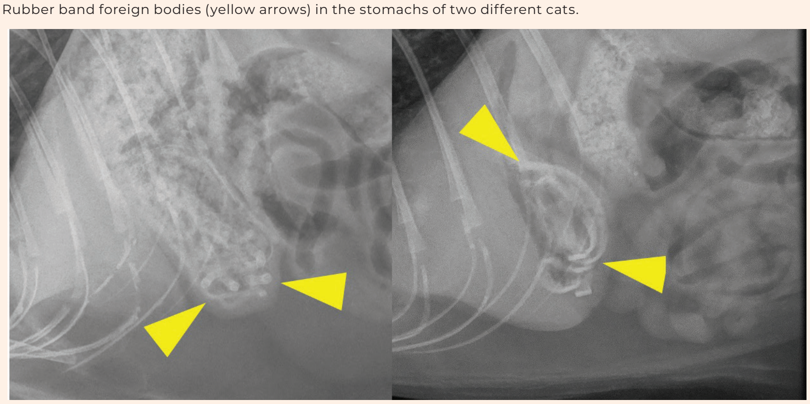


Figure 2

» Rubber band foreign bodies (yellow arrows) in the stomachs of two different cats.



Rubber bands (e.g., hair ties) are also commonly ingested, especially by cats. Like rubber balls, these are almost invariably detectable radiographically, usually as linear mineral opacities that may or may not form complete rings (Figure 2).

Corn Cobs

Corn cob foreign bodies are common and frequently obstructive in dogs, especially during fresh corn season (summer to early autumn). If the dog chewed the corn cob into small pieces, they would likely be unidentifiable as corn cob, essentially looking like normal ingesta (and likely not clinically significant). But if the corn cob segment was partially or fully intact when swallowed, it may be readily visible on radiographs. The most common appearance of a corn cob is of a rectangular or cylindrical object of mixed soft-tissue and gas opacity, with a pattern of stippled gas regularly spaced in a grid that corresponds to the distribution of corn kernels on the cob (Figure 3). The "sockets" that hold the corn kernels will entrap gas, creating this regular grid pattern radiographically.

Stone Fruit Pits

The pits from peaches, plums, apricots, and other similar stone fruit have a characteristic appearance radiographically. They are almond-shaped mixed opacity objects, usually with a gas lucent center and soft tissue to a mineral opaque wall (Figure 4). The wall of the fruit pit is only faintly mineral in opacity. When surrounded by fluid, it can be a very subtle lesion as the gas lucency in the center can resemble normal intestinal gas. The ridges of the pit can also create linear opacities over the gas center, creating a slightly striated appearance.

Tree Nuts

Although somewhat uncommon as obstructive foreign bodies, certain tree nuts with strong shells or coats, such as chestnuts, walnuts, pistachios, hazelnuts, and acorns, can be radiographically visible. These tend to be more challenging to identify, as they do not have a gaseous or hollow center, unlike stone fruit pits. The nut meat is usually of a soft tissue opacity, and the shell is usually also of a soft tissue

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Figure 3

» Small intestinal corn cob foreign bodies in three dogs (yellow arrows). The bottom two images are from the same dog. Note the regular grid-like pattern of stippled gas, characteristic of corn cobs.

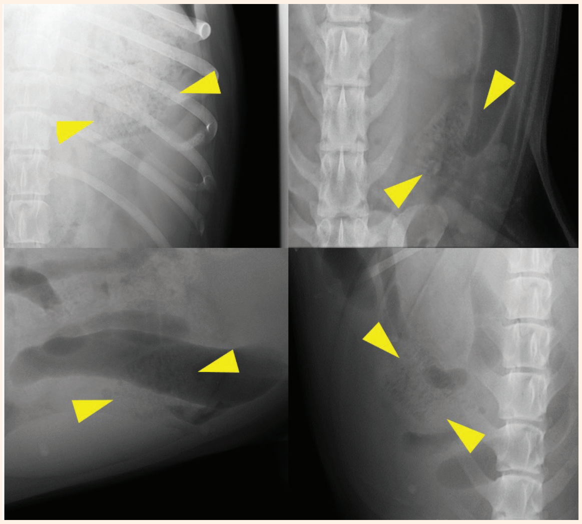


Figure 4

» Peach pit foreign bodies in three different dogs (yellow arrows). Note the faintly mineral opaque walls forming an almond shape surrounding a central gas lucency.

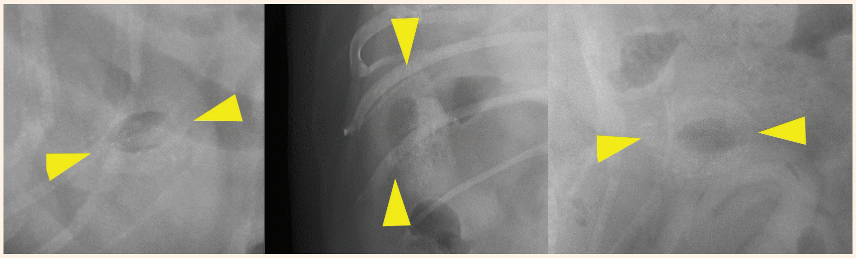
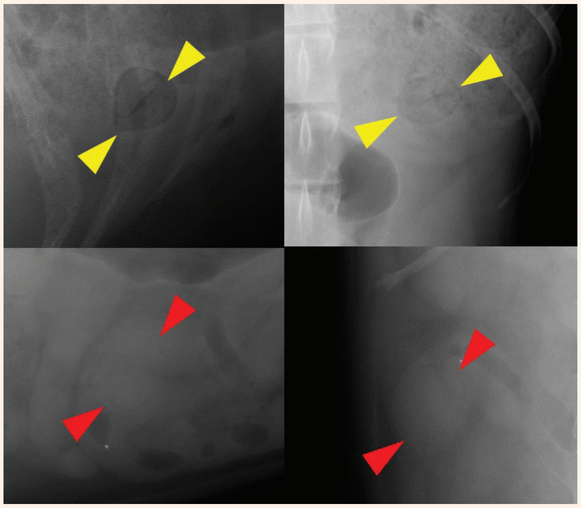


Figure 5

» A chestnut foreign body in the stomach of a dog (yellow arrows) and an acorn foreign body in a dog's small intestine (red arrows). Note the rim of gas surrounding the nut meat within the shell. The gas is relatively thin and subtle in the acorn.



opacity. But some gas can be present between the nut meat and the shell, creating a distinct outline of the foreign body (Figure 5).

Fabric

Fabric foreign material, such as articles of clothing or fragments of towels and sheets, generally are of a soft tissue opacity with numerous characteristic striations that distinguish it from normal ingesta (Figure 6). Fabric foreign material may or may not have associated intestinal plication, depending on whether frayed threads create a concurrent linear component. The fabric can also mimic formed feces in the colon, as there is often some amount of entrapped gas and a somewhat amorphous, tubular shape.

Trichobezoars

Trichobezoars, or hairballs, can be obstructive in cats, especially cats with an underlying diffuse enteropathy such as inflammatory bowel disease or small cell alimentary lymphoma. While hairballs are more common in long-haired cats, they can also form in short-haired cats. Trichobezoars can be very challenging to positively identify on radiographs, as they have an amorphous and fairly nondescript appearance. But they are characterized by a somewhat stippled gas pattern within an otherwise discrete small intestinal soft tissue opacity (Figure 7).

They are essentially indistinguishable from formed feces in the colon and are generally not identifiable in the stomach. When the hairball can be isolated to a small intestinal segment, separate from the colon, the index of suspicion based on plain radiographs can be quite high. Anecdotally, trichobezoars are more likely to pass with supportive care and IV fluid therapy than other obstructive foreign bodies.

Bismuth Subsalicylate (Pepto-Bismol)

Although technically not a foreign body, it is notable that due to the bismuth, which is a metallic element with an atomic number of 82, Pepto-Bismol and other bismuth-based gastroprotectants will have a radiopaque appearance, generally of a mineral or metal opacity (Figure 8).

This usually only becomes clinically relevant if a client has administered the medication in tablet form and did not inform the veterinarian. In liquid form, the bismuth rapidly dilutes and may simply look like a small amount of non-obstructive granular mineral material. But as an intact tablet, Pepto-Bismol very much resembles a foreign body. Reports show that sucralfate can have a similar radiopaque appearance (again, when given in tablet form) as it is an aluminum salt. Still, anecdotally, the author has never seen sucralfate

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Figure 6

» A sock foreign body in the stomach of a dog, extending into the duodenum (yellow arrow). Note the characteristic striations identifying the foreign material as having a fabric composition.

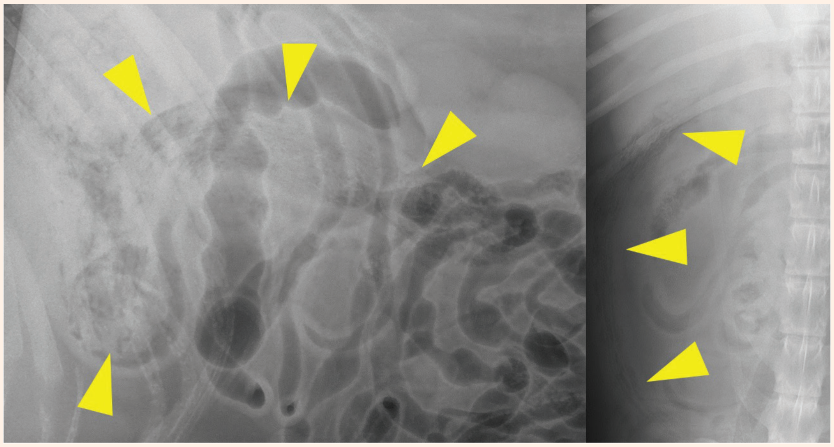

Figure 7

» Jejunal trichobezoars in two cats (yellow arrows). Note how both hairballs are amorphous and conform to the shape of the intestinal lumen. Both have a mixed soft tissue/gas opacity and have a fairly subtle appearance which could easily be confused with fecal material in the colon.

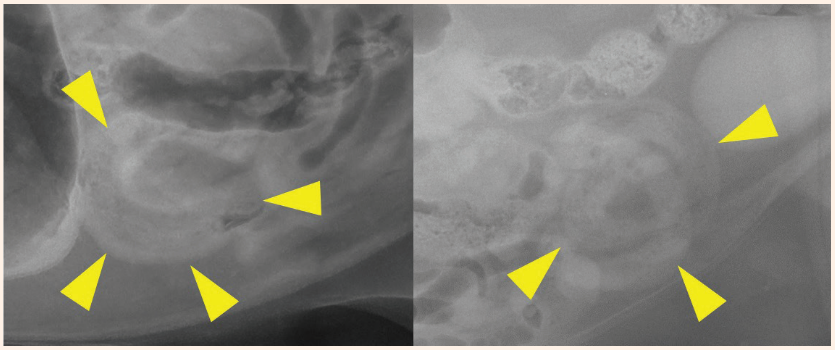

Figure 8

» **Left** - Bismuth subsalicylate (Pepto-Bismol) tablets in a dog's stomach. **Right** - Synthetic bismuth metal crystals (source: Wikipedia).

be confused for foreign material on a radiograph. Aluminum has a much lower atomic number (13). It has a mineral opacity on radiographs, and the amount of aluminum in sucralfate is small enough that it typically is not radiographically visible.

Summary

Although this article demonstrates the characteristic radiographic appearance of some common gastrointestinal foreign bodies in dogs and cats, it is important to note that the presence of an identifiable foreign body does not automatically equate to an indication for surgical exploration. Many non-obstructive foreign bodies, even if obstructive, may pass with supportive care, including IV fluid therapy. But being able to recognize a foreign body radiographically (especially more subtle ones like tree nuts or trichobezoars) can aid in recommending follow-up imaging, given that the foreign body is detectable on plain radiographs. Note that orthogonal projections (ideally right lateral, left lateral, and ventrodorsal) are still recommended with radiographically visible foreign bodies, as sometimes the superimposition of the various intestinal segments may obscure the foreign body on any single view.

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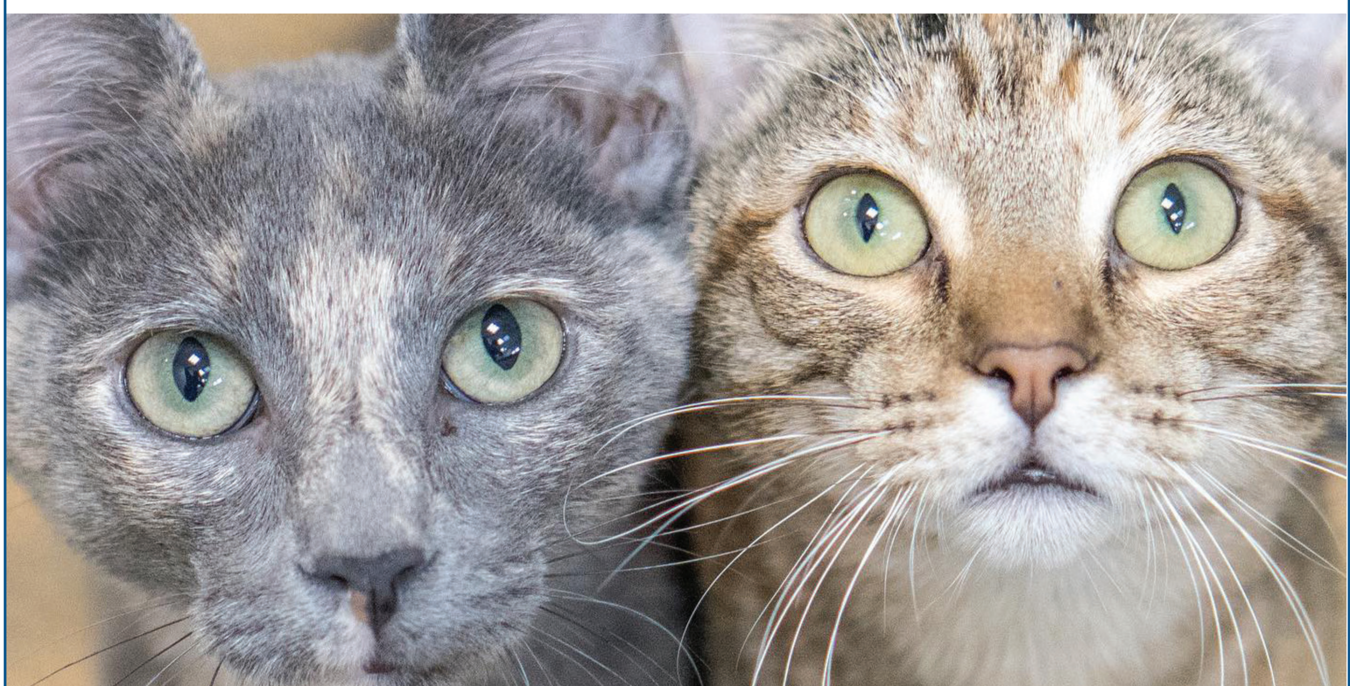

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