

Anthony Fischetti DVM, MS
Diplomate, American College of Veterinary Radiology
Department Head, Diagnostic Imaging; Schwarzman Animal Medical Center, NYC
Owner/Consultant, Veterinary Imaging of New York
Anthony.fischetti@amcny.org

Final Sessions: Case Challenges!!

Our final discussions in diagnostic imaging and radiology will focus on case presentations. Everyone is welcome to partake. Each case will start with a brief history, to include signalment. Imaging in the form of radiographs, ultrasound and even a couple of MRIs and CTs will be presented. I will make sure to have histological or other follow up for all the cases.

The cases will concentrate on various diseases of older cats and dogs, including chronic endocrinopathies and their imaging manifestations. Below are some notes that you may find handy after our discussion.

Ultrasound Checklist for the Diabetic Dog

Ultrasound is often utilized in the work-up of diabetes mellitus (DM) in dogs and cats. Imaging becomes especially crucial for pets that are ketotic (diabetic ketoacidosis: DKA). The following discussion illustrates common abnormalities seen in the diagnostic imaging work-up of the diabetic dog.

Liver:

Liver abnormalities, both biochemical and anatomic, are common in diabetic dogs. The classic diffuse hepatopathy of a diabetic dog consists of a hyperechoic, finely echotextured and large liver. Concurrent hypo- or hyperechoic nodules are also very common, associated with nodular hyperplasia. These nodules are homogenous in internal architecture and rarely deform the liver capsule. Hypoechoic nodules tend to appear more conspicuous as the background liver becomes more hyperechoic. The differential diagnosis for this type of diffuse hepatopathy includes vacuolar hepatopathies, hepatitis, and diffuse liver neoplasms such as mast cell tumor and lymphoma.

Gallbladder:

Unlike with Cushing's disease, there is no association between gallbladder mucocele formation or excessive gallbladder sludge/inspissation in dogs with DM. Variable amounts of gallbladder sludge that eventually settle to the dependent wall are common in normal dogs. With that said, a concerted effort is always made to assess the

gallbladder wall and bile ducts for any evidence of chronic cholecystitis that could complicate treatment for diabetes.

Pancreas:

Assessment of concurrent acute or chronic pancreatitis in dogs with DM is crucial, especially in DKA. Acute pancreatitis can occur in over 40% of dogs with DKA. The acutely inflamed pancreas classically appears hypoechoic and large, with surrounding hyperechoic (steatitic) fat. Dogs show evidence of pain on ultrasound interrogation of the pancreas. Free peritoneal effusion tends to accumulate cranially in the peritoneum, likely associated with congestion or peritonitis. The adjacent colon and duodenum may be corrugated and thick walled. In acutely necrotic forms of pancreatitis, loss of color Doppler signal may be noted in areas of the pancreas that are hypoechoic or anechoic (pseudocyst formation or pancreatic abscesses may evolve and should be monitored over time).

In chronic pancreatitis, the pancreas becomes diffusely hyperechoic with distal attenuation, perhaps related to fat or fibrosis infiltrating the organ. This appearance of the pancreas has also been described in dogs with chronic Cushing's syndrome.

Gastrointestinal Tract:

The relationship of DM and chronic GI signs in dogs and cats is poorly understood, but in people with DM it is well established that DM results in loss of neurons causing dysmotility and altered secretions within the entire GI tract (visceral neuropathy). The internists at the Schwarzman Animal Medical Center will often ask if there is any evidence of fluid retention in the stomach or intestines as a sign of GI motility issues. Focal enteritis (duodenum and colon) is common for intestines in proximity to a severely inflamed pancreas.

Spleen:

An underreported phenomenon of organ speckling occurs with endocrinopathies in dogs (most commonly, DM and hypothyroidism). Multifocal hyperechoic speckles are most conspicuous in the spleen but can also be seen in the kidneys and other abdominal organs. These speckles may be related to dystrophic mineralization, but the foci are very small and do not cast a shadow. The clinical relevance of these speckles is unknown, perhaps associated with chronicity of the endocrinopathy.

Adrenal Glands:

The imaging relationship of DM and the adrenal glands has different implications for the dog versus the cat.

In dogs, Cushing's syndrome (CS) is a known cause of diabetes mellitus, occurring in up to 16% of dogs with CS. High circulating concentrations of glucocorticoids can increase hepatic gluconeogenesis and impair insulin function. Diabetic dogs with concurrent CS

need higher doses of insulin and have shorter survival times compared with diabetic dogs without CS.

Knowing this, evaluation of size, shape and echogenicity of the adrenal glands is an important part of the ultrasound checklist for these diabetic dogs. Normal adrenal size in dogs has been studied extensively. The two most important factors affecting adrenal size are (1.) the size of the patient and (2.) the presence of concurrent non-adrenal illness. The diabetic dog is by definition a patient with non-adrenal illness; so, the rule-of-thumb for a diabetic dog under 12 kg and without CS is <0.62 cm adrenal thickness (largest dimension of the caudal pole perpendicular to the longitudinal axis of the gland). For diabetic dogs over 12 kg without CS, adrenal gland thickness should be <0.72cm. Yes, normal dogs over 20kg can have adrenal glands up to 0.8 cm, but in the case of a known diabetic, we are not evaluating a normal dog! Non-adrenal illness should lower our threshold for previously reported normal adrenal gland measurements.

Kidneys:

DM should always alert clinicians to search for concurrent urinary tract infections. Kidney-related changes associated with infection include loss of normal architecture, variable degrees of pelvic dilation, and a decrease in kidney size or altered shape. Calculi formation secondary to chronic infection are most commonly struvite in composition. Struvite calculi may form a staghorn shape in the kidney on radiographs, conforming to the shape of the renal pelvis. Struvite calculi tend to have the opacity of medullary bone (less opaque than calcium oxalate) and can get rather large. Predicting stone composition on ultrasound is not as reliable as radiographs. A recent study showed excellent ability to predict stone type using signalment, urinalysis and abdominal radiographs.

Urinary Bladder:

Again, the typical changes expected of chronic infection should apply to the urinary bladder of DM in dogs. Cystitis tends to yield a thickening to the cranial (apex) of the urinary bladder wall, more so relative to the trigone. Wall thickening should always be considered relative to the degree of bladder filling. The mucosal surface of the urinary bladder wall can be hyperechoic and irregular. Shadowing calculi (struvite composition) in the urinary bladder of a diabetic dog with a urinary tract infection may also be seen. Polypoid cystitis may also be seen in diabetic dogs or any dog with signs of chronic lower urinary tract disease. The polyps tend to form at the apex of the urinary bladder (like areas of wall thickening seen with non-polyp forming cystitis). The polyps tend to be pedunculated and multifocal. The etiology of polyp formation remains unknown but may be related to hyperplasia of the mucosa in response to chronic irritation (eg from stones, primary inflammatory conditions, and/or infection). Polyps can be differentiated from urinary bladder neoplasia by location and shape but overlap

between the two entities exists. BRAF testing or sampling may be needed to differentiate in some cases.

In severe, untreated urinary tract infections we can see the development of intra-mural gas in the urinary bladder (or even tracking into the kidneys). *Emphysematous cystitis* was first described as a phenomenon of chronic DM or cushingoid dogs. Since the first reports, emphysematous cystitis has been seen in all sorts of chronic infections, not limited to chronic endocrinopathies. Another form of severe cystitis that may confuse a sonographer is *encrusting cystitis* (mineralization of the wall). Encrusting cystitis was traditionally seen with *Corynebacterium* infections but has since been seen with various isolates. Gas and mineral in the wall should be differentiated from calculi formation in the bladder lumen.

Eyeballs?

Yes, eyeballs. At the Schwarzman Animal Medical Center, diabetic dogs with cataracts may undergo high frequency ocular ultrasound for evaluation of orbital and retro-orbital diseases that could go unnoticed because of the presence of the cloudy lens. Prior to phaco-emulsification, we will investigate for concurrent retinal detachment, ocular tumors, and/or retrobulbar masses that could influence the success of the procedure. It is important to have a high frequency ultrasound transducer (over 12 MHz) with a narrow footprint. A “hockey-stick” transducer is best for imaging small superficial structures like the globe. The high cost of this transducer does, however, make it impractical for routine screening in general practice.

References:

Perez-Lopez, L, Mendoza P, Melian C. Effects of concurrent canine Cushing’s syndrome and diabetes mellitus on insuline requirements, trilostane dose, and survival time. Research in veterinary science, June 2023. <https://doi.org/10.1016/j.rvsc.2023.06.003>

Bento PL, Center SA, Randolph JF, et al. Association between sex, body weight, age and ultrasonographically determined adrenal gland thickness in dogs with non-adrenal gland illness. J Am Vet Med Assoc. 2016 Mar 15;248(6):652-60. Doi:10.2460/javma.248.6.652.

Hume DZ, Drobatz KJ, Hess RS. Outcome of dogs with diabetic ketoacidosis: 127 dogs (1993-2003). J Vet Intern Med. 2006 May-Jun;20(3):547-55. Doi:10.1892/0891-6640(2006)20

Martinez I, Mattoon JS, Eaton KA, et al. Polypoid cystitis in 17 dogs (1978-2001). J Vet Intern Med 2003;17:499-509. Doi:10.2460/javma.242.6.798.

Biegen VR, Slusser PG, Fischetti AJ, et al. Successful treatment of encrusted cystitis with *Staphylococcus pseudointermedius* infection in the urinary bladder of a dog. *J Am Vet Med Assoc* 2013 Mar 15;242(6):798-802.

Maurey C, Boulouis HJ, Canonne-Guibert M, et al. Clinical description of *Corynebacterium urealyticum* urinary tract infections in 11 dogs and 10 cats. *J Small Anim Pract*. 2019 Apr;60(4):239-246. Doi:10.1111/jsap.12973.

Diagnostic Imaging of Geriatric Cats

Systemic Hypertension

Systemic hypertension is a common complication of chronic endocrinopathies in older cats, particularly hyperthyroidism and chronic renal disease. Imaging features (from radiographs to MRI) can alert clinicians to the suspicion of chronic hypertension. The pathologic effect of systemic hypertension on tissues is referred to as “Target Organ Damage” (TOD). TOD can result when systolic BP reaches 150-160 mmHg. A variety of tissues can be affected, including cardiovascular, kidneys, eyes, and CNS.

A. Cardiovascular TOD:

Aortic Remodeling: Studies have been inconsistent as to how the aorta is altered in feline hypertension. A more recent study supports three specific thoracic radiographic abnormalities that are associated with systemic hypertension in cats:

- (1.) thoracic aortic undulation on the LAT thoracic radiographic projection,
- (2.) disparity in diameter of the ascending and proximal descending aorta on the LAT thoracic radiographic projection.
- (3.) Lateral bowing of the aortic arch (the aortic knob) on the VD thoracic radiographic projection.

An “aortic remodeling-adjacent” finding that may indirectly be associated with systemic hypertension is aortic mineralization. A mineralization to the walls of the aorta can occur with chronic hyperphosphatemic renal disease. With time, the calcium/phosphorus imbalance can also lead to mineralization of the stomach wall, kidneys, and branches of the aorta (eg mesenteric root).

B. Kidney TOD:

Any imaging finding associated with chronic renal disease should alert clinicians to the possibility of secondary systemic hypertension. Normal kidneys in spayed/castrated cats range from 1.9 to 2.6 times the length of a lumbar vertebra (L2). Radio-opaque renal calculi in cats are almost exclusively calcium oxalate in composition.

C. Ocular and CNS TOD:

MRI findings associated with hypertension include retinal detachment. We may identify retinal detachment on MRI while imaging cats for vascular compromise (stroke) or for further evaluation of presumed “hypertensive encephalopathy”. Hypertensive encephalopathy is often a clinical suspicion, rarely imaged. Signs and imaging findings will resolve once the hypertension is treated.

Hyperthyroidism

Imaging findings of feline hyperthyroidism is non-specific. Radiographs may suggest a thin body condition, well inflated lungs, and mild cardiomegaly (thyrotoxic cardiomyopathy). Hyperthyroid cats often experience the secondary target organ damage described for systemic hypertension (described above). Imaging of thyroid lobes is less common (including ultrasound and nuclear imaging).

On routine ultrasound imaging of geriatric cats, mild bilateral adrenomegaly (~5-7 mm) will raise the question of hyperthyroidism. The adrenomegaly is most likely associated with the hypersecretion of the adrenal cortex. Hyperthyroidism should be an alternative to hyperadrenocorticism, hyperaldosteronism, and acromegaly in cats with bilateral moderate adrenomegaly.

Hyperaldosteronism

Hyperaldosteronism (Conn’s Syndrome) is rare relative to hyperthyroidism but can be prioritized in cats presenting with profound weakness, PU/PD, ventroflexion of the neck, and hypokalemia. Adrenal enlargement is usually UNILATERAL (functional carcinoma), but bilateral enlargement (adenomas) has been documented as well.

A subset of feline hyperaldosteronism has been more recently described in cats that secrete not only aldosterone but additional corticosteroids (progesterone). All these cats were concurrently diabetic. All cats had large unilateral adrenal masses and small or undetectable contralateral adrenal glands.

Acromegaly

Acromegaly (hypersomatotropism with associated enlargement of bones/soft tissue of the head and other internal organs) is caused by the presence of growth-hormone (GH)-secreting tumor in the anterior lobe of the pituitary gland. Elevations in IGF-1 in cats with insulin-resistant diabetes will generally confirm the diagnosis.

Additional diagnostics to support a diagnosis of acromegaly could include abdominal ultrasound, thoracic radiographs, and CT/MRI imaging of the head. Enlargement of the

heart, liver, kidneys and other imaged organs is common with radiographs/ultrasound. Pituitary enlargement can be seen on imaging of the head (CT/MR). Additionally, frontal bossing (outward bony thickening of the frontal bones) and swelling of the soft tissues of the oral cavity and larynx may be seen. This swelling of soft tissues in the neck can be associated with chronic upper airway congestion.

Hyperadrenocorticism

An important differential with acromegaly, hyperadrenocorticism in cats may present with similar signs, including pituitary enlargement (due to functional adenoma).

Approximately 20% of cases of feline hyperadrenocorticism are related to a functional adrenal tumor (adenoma or carcinoma). Since cortisol antagonized insulin, ~80% of these cats will develop diabetes. The overlap in imaging features AND clinical presentation with other endocrinopathies is hair raising!

Adrenal Imaging in Cats/Take Home Points:

- Normal adrenal glands are 3-5 mm thick; 30% of normal cats have adrenal mineralization
- Bilateral mild adrenomegaly is most commonly seen with hyperthyroidism. DDX: hyperadrenocorticism, hyperaldosteronism, hypersomatotropism
- Primary hyperaldosteronism is most commonly seen as a unilateral adrenomegaly, less commonly seen with bilateral adrenomegaly

Pituitary Imaging in Cats/Take Home Points:

- Two differentials for pituitary adenoma formation in cats: acromegaly and hyperadrenocorticism (both associated with diabetes mellitus).
- Calvarial thickening and swollen soft tissues of the neck only with acromegaly
- Closely assess globes for retinal detachment when assessing head/neck CT or MRI in older cats

References:

Ramspott S, Hartmann K, Sauter-Lous C, et al. Adrenal function in cat with hyperthyroidism. J Feline Med Surg. 2012 Apr;14(4):262-6.

Doi:10.1177/1098612X11435893

Combes A, Vandermeulen E, Duchateau Luc, et al. Ultrasonographic measurements of adrenal glands in cats with hyperthyroidism. Vet Radiol Ultrasound. 2012 Mar-Apr;53(2):210-6. Doi:10.1111/j.1740-8261.2011.01888.x

Stephien RL. Feline hypertension: diagnosis and management. J Feline Med Surg. 2011 Jan 13(1):35-43. Doi:10.1016/j.fms.2010.11.008

Tras AM, Abbott BL, French A, et al. Congenital thyroid hypoplasia and seizures in 2 littermate kittens. J Vet Intern Med 2008;22(6):1427-1431. Doi:10.1111/j.1939-1676.2008.02023.x

Stromberg SJ, Yan J, Wisner TG, et al. Clinical features and MRI characteristics of retinal detachment in dogs and cats. Vet Radiol Ultrasound. 2021 Nov;62(6):666-73. Doi: 10.1111/vru.12999.

Griffin S. Feline abdominal ultrasonography: what's normal? What's abnormal? The adrenal glands. J Feline Med and Surgery. 2021 Jan 6.

<https://doi.org/10.1177/1098612X20979509>

Fischeti AJ, Gisselman, Peterson ME. CT and MRI evaluation of skull bones and soft tissues in 6 cats with presumed acromegaly versus 12 unaffected cats. Vet Radiol Ultrasound. 2021 Sep-Oct;53(5):535-59.doi:10.1111/j.1740-8261.2012.01957.x.