SMALL ANIMAL PROCEEDINGS

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What's New at KSU? Minimally Invasive Procedures

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What's New at KSU? Minimally Invasive Procedures

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Minimally Invasive Procedures

Introduction

- Interventional radiology (IR) refers to image-guided interventions which are typically less invasive than traditional procedures
- Interventional endoscopy (IE) encompasses standard endoscopic equipment and the use of different imaging modalities (typically fluoroscopy) as well as other pieces of equipment that can be utilized for both diagnostic and treatment purposes
- IR/IE provides an alternative for patients and sometimes allows us to "treat the untreatable"
- Less is more:
  - Less invasive
  - Less morbidity and mortality
  - Less hospitalization time
  - Less cost
  - Less traditional approaches

Outline and Select Procedures at KSU

- Acute kidney injury and post-renal causes
  - Ureteral obstructions
    - Dogs: endoscopic retrograde ureteral stenting
    - Cats: subcutaneous ureteral bypass device placement
  - Urethral obstructions
    - Urethral stent placement
    - Laser lithotripsy
- Cystoscopic-guided laser ablation of ectopic ureters
- Tracheal stent placement
- Laparoscopic liver biopsy and percutaneous cholecystectomy

Acute Kidney Injury

Post-Renal Azotemia

- Azotemia caused by obstruction of the urine collecting system
  - Ureteral
  - Urethral
- Urinary obstructions cause an obstructive nephropathy leading to a decrease in glomerular filtration rate, decrease in renal blood flow, endothelial dysfunction, and tubular and interstitial damage from inflammation, edema, and necrosis

Ureteral Obstructions

- Ureteral obstructions (even partial ones) can cause irreversible renal damage
  - Experimentally induced ureteral obstruction in dogs produced the following effects on glomerular filtration rate (GFR)[1-3]
    - If present for 7 days – 70-80% of GFR returned

        - If present for 14 days – 40-50% of GFR returned
        - If present for 28 days – 25% of GFR returned
        - If present for >42 days – 0% of GFR returned
- Ureteral obstructions are more common in cats than dogs but can occur in both species
- Differentials[4]
    - Ureterolithiasis
        - 98% of upper urinary tract stones in cats are calcium oxalate[5]
        - Medical dissolution of ureteroliths is unsuccessful and should not be attempted
    - Strictures
    - Neoplasia of the ureter or trigone
    - Dried solidified blood clots
    - Curcumcaval ureter (right-sided more common than left-sided)
    - Severe ureteritis
    - Trauma (iatrogenic surgical ligation)
    - Ureteral stenosis at an ectopic ureter opening
- 15-20% of cats with ureteral obstructions are bilaterally obstructed[5]
- Diagnosis
    - Degree of azotemia varies but may be severe
    - Hyperkalemia may be present
    - Abdominal imaging needed to evaluate for post-renal causes of azotemia
        - Abdominal radiographs and ultrasound have similar sensitivity (~80%) for identification of ureteroliths
        - Abdominal ultrasound is recommended to evaluate for hydoureter and hydronephrosis since some ureteroliths and other causes of ureteral obstructions may be missed with radiography
        - A renal pelvis ≥13 mm is strongly suggestive of an obstruction,[6] but obstructions can be seen with renal pelvis dilations of lesser degree[7]
- Medical management is recommended initially, but this is considered a surgical disease
    - Intravenous fluid therapy, diuretics (mannitol), antispasmodic medications, analgesia, +/- antimicrobials
    - Allows for correction of hemodynamic abnormalities prior to general anesthesia
    - Successful medical management and documentation of stone passage is ~10%[8]
- Traditional surgical procedures (ureterotomy reimplantation, ureteroneocystostomy, ureteral resection and anastomosis, ureteronephrectomy) have fallen out of favor due to their relatively high morbidity and mortality rates compared to other interventional procedures[8-11]
- Some of these patients may have a concurrent bacterial infection
- Due to both functional and structural changes to the urinary system including device placement, some of these bacterial infections may be difficult to reliably clear

<u>Ureteral Stents</u>

- Ureteral stents lead to passive ureteral dilation
- Ureteral stents can be placed surgically in cats with ureteral obstructions from stones but is currently not the treatment of choice due to poor outcomes when compared to subcutaneous ureteral bypass (SUB) devices[12,13]
- Canine ureteral obstructions from ureteroliths are typically managed with double-pigtail ureteral stents instead of SUBs since they can be placed endoscopically
- Complications
    - Complication rate overall appears to be relatively low[14]
    - Major complications (5%) may include ureteral perforation, ureteral avulsion, and shearing of the coating of the guidewire leading to obstruction of the stent

    - Other complications may include hematuria, stent migration, stent occlusion, proliferative tissue growth at the ureterovesicular junction, and presumed ureteritis (2-9% of each), or recurrent urinary tract infections (26%)
    - Stent exchange or replacement with a SUB device needed in 16% of cases
- SUBs can be placed in dogs if a laparotomy is performed and is more ideal in cases where a ureteral stricture is present

Subcutaneous Ureteral Bypass Devices

- 6.5 Fr polyurethane catheter composed of a locking-loop nephrostomy catheter, multi-fenestrated cystostomy catheter, and metallic shunting port (Norfolk Vet Products, Skokie, IL, USA)
    - Ventral midline laparotomy required
    - Nephrostomy catheter is typically placed with fluoroscopic guidance into the caudal pole of the obstructed kidney
    - Cystostomy catheter is placed into the apex of the urinary bladder
    - Both nephrostomy catheter and cystostomy catheter exit the abdominal wall and attach to a shunting port that sits in the subcutaneous space
- Does not remove the ureteral obstruction or address the obstructive lesion directly
- Instead, it bypasses the obstruction creating an alternate route for urine to flow to the urinary bladder
- Complications[4,15,16]
    - SUB device occlusion
        - Approximately 10-20% chance of occlusion after device placement
        - Intermittent SUB flushing is recommended due to development of encrustation
        - Could be due to tube kinking
    - Leakage from the device (shunting port or at the nephrostomy or cystostomy tube insertion site)
    - Dysuria
        - May be able to medically manage the iatrogenic cystitis
        - Rarely trimming of the cystostomy catheter in the urinary bladder or catheter exchange is needed
    - Hematuria
- Outcome[15-17]
    - Median survival times range from 1.5-3.5 years
        - May depend on degree of AKI and resulting CKD
    - Approximately 5-10% perioperative mortality rate

Urethral Obstructions

- Another cause of post-renal azotemia
- Clinical signs of lower urinary tract disease (dysuria, pollakiuria, stranguria, hematuria) may precede a urethral obstruction (stranguria with inability to pass urine)
    - Clinical signs can sometimes be misinterpreted by owners as constipation, back pain, or abdominal pain
- Differentials[18]
    - Urethrolithiasis
        - Most common cause in dogs
    - Crystalline-matrix urethral plugs
        - Most common cause in cats (along with urethroliths)
    - Neoplasia of the urethra, trigone, or prostate
    - Urethral stricture

    - Severe ureteritis
    - Functional disease
        - Detrusor-urethral dyssynergia
        - Upper motor neuron bladder
- Diagnosis
    - Diagnosis of a urethral obstruction is typically made based on history and physical examination
        - Large, firm urinary bladder
        - For stable patients try to witness the patient's ability to urinate
    - May be systemically ill depending on the severity and duration of disease
    - Be sure to evaluate for bradycardia which can be a result of hyperkalemia
        - Electrocardiogram changes with hyperkalemia
            - Blunted p waves
            - Prolonged PR interval
            - Widened QRS complexes
            - Tall, tented t waves
            - Can progress to atrial standstill

<u>Urethral Stents</u>

- Self-expanding laser cut metallic stent placed under fluoroscopic guidance in dogs
- Performed as a palliative procedure for urethral obstructions
    - Neoplasia (prostatic carcinoma most common)
    - Strictures
    - Extrinsic urethral compressions
    - Refractory detrusor-urethral dyssynergia
- May improve quality of life in those patients with both complete and partial urethral obstructions
- Complications[19-21]
    - Urinary incontinence
        - Males: 75% become incontinent with 1/3 severe, 2/3 mild
        - Females: 50% become incontinent with 1/2 severe, 1/2 mild
    - Need for repeat procedures in 20%
        - More likely from tumor growth and obstruction beyond the stent ends as opposed to tumor ingrowth through the stent
        - Tissue ingrowth more common for urethral strictures

Urolithiasis

<u>General Management Strategies</u>

- Medical dissolution for uroliths that are amenable to medical dissolution (struvite, urate, cystine) should be attempted first if possible
- Stone analysis is the only way to definitively diagnose the stone composition, but our urinalysis may help give us hints
    - Crystalluria may sometimes suggest stone type
    - Urine pH may affect risk of stone formation
        - Acidic pH: calcium oxalate, urate, cystine, xanthine
        - Alkaline pH: struvite, calcium phosphate, calcium carbonate
    - Urine culture: presence of urease-producing bacteria leads to struvite formation
        - Most common are *Staphylococcus spp.* and *Proteus spp.*
- Indications for removal of lower urinary tract calculi[4,22]

    - Calculi not amenable to medical dissolution
    - Obstructive urethrolith
- Urocystolith removal procedures
    - Voiding urohydropulsion
    - Cystoscopic-guided laser lithotripsy and basket retrieval
    - Percutaneous cystolithotomy

Laser Lithotripsy

- Uroliths are fragmented using a holmium:yttrium-aluminum-garnet (Hol:YAG) laser until they are small enough to pass through the urethra
- Typically removed through cystoscopic-guided basket retrieval
- Ideally evaluate for bacteriuria prior to procedure
- Lithotripsy candidacy determined on a case-by-case basis, but general criteria are:
    - Female dogs
        - No more than 2-4 uroliths (depends on size of patient and size of uroliths)
        - Urocystoliths ideally ≤10 mm (≤5 mm for small dogs)
        - Patient weight >8 lbs (smallest rigid cystoscopy is 11.5 Fr)
    - Male dogs
        - No more than 2 uroliths
        - Urocystoliths ≤5 mm
        - Must be able to easily pass an 8 Fr red rubber catheter through urethra (flexible scope diameter is 8.5 Fr)
    - Female cats
        - No more than 2 uroliths
        - Urocystoliths ≤5 mm
        - Patient weight >8 lbs (smallest rigid cystoscopy is 11.5 Fr)
    - All male cats are not good candidates for lithotripsy due to their small size
- Complications (Up to 18%)[23]
    - Urethritis (may require temporary indwelling urinary catheterization after the procedure)
    - Urethral tears
    - Urethral stricture
    - Hemorrhage
    - Urinary bladder perforation or rupture
- Procedure success rate is higher with females, higher body weight[23,24]

Urinary Incontinence

Ectopic Ureters

- Ectopic ureters (EU) are the most common cause of congenital urinary incontinence
- Termination of one or both ureters at a different location other than the trigone
- Can be unilateral or bilateral
- Can be intramural or extramural
    - Intramural → ureter enters the trigone but tunnels before opening into the urethra distally (approximately 95% of cases)
    - Extramural → ureter bypasses the trigone completely and enters distally in the urethra (or vagina or vestibule in females)
- Can be associated with other urinary abnormalities
    - Ureterocele
    - Hydroureter
    - Hydronephrosis

    - Vaginal septal remnants
    - Persistent urachus
    - Renal aplasia, hypoplasia, or dysplasia
    - Pelvic bladder
    - Vulvovaginal strictures
- Approximately 2/3 of patients with EU have bacteriuria, so culture and appropriate treatment should ideally be instituted prior to referral
- Diagnosis
    - Need to evaluate for abnormal ureteral opening(s) and evaluate for concurrent congenital problems
    - Females – 2 options[25]
        - Cystoscopy and abdominal ultrasound
            - Cystoscopy allows for visualization of EU openings, but we cannot evaluate the ureters or kidneys (for abnormalities like hydroureter and hydronephrosis)
                - Intervention may also be performed at this time
                - Cannot accurately evaluate for intramural vs. extramural
            - Abdominal ultrasound should be performed beforehand to evaluate for hydronephrosis, hydroureter, etc.
                - Ultrasound has a low sensitivity for detecting EU
        - Computed tomography with excretory urography
            - May identify EU
            - Potential to evaluate for intramural vs. extramural
            - Multiple scans may be required due to ureteral peristalsis
    - Males
        - Computed tomography with excretory urography is the ideal diagnostic for males as it may be more difficult to identify ectopic ureters on cystoscopy[26]
            - Ureteral openings are often stenotic
            - Colliculus seminalis, ductus deferens, and prostatic duct openings should not be mistaken for EU

<u>Cystoscopic-guided Laser Ablation of Ectopic Ureters</u>

- Cystoscopic-guided laser ablation of ectopic ureters (CLAEU) can be performed at the time of cystoscopic diagnosis of EU
- Only a treatment option for intramural EU
    - Retrograde ureteropyelography is performed with rotational fluoroscopy to confirm intramural status
    - Ureteral catheter is placed
    - Medial aspect of the EU wall is cut cranially using a Ho:YAG or diode laser over a ureteral catheter until the opening is in the urinary bladder
- Vaginal septal remnants can be cut after CLAEU
    - These remnants could lead to vaginal pooling and increase risk for development of urinary tract infections
- Complications
    - Perforation
        - Retrograde urethrocystogram and ureteropyelogram performed after CLAEU to confirm there is no extravasation
    - Delayed laser reaction → proliferative reaction along the laser tract that can cause ureteral obstruction (uncommon)[4]
- Outcome

- Approximately 50% of female dogs are continent after CLAEU
- Other 50% have concurrent urethral sphincter mechanism incompetence requiring medical management
- Continence is achieved in approximately 80% of male dogs after surgical correction,[26] similar to what is reported with CLAEU[4]

Respiratory

Tracheal Stents

- Mesh self-expanding metallic stents
- Intraluminal tracheal stenting usually placed with fluoroscopic guidance
- Potential indications
  - Dyspnea secondary to tracheal collapse
  - Obstructive tracheal lesions
    - Masses
    - Strictures
- Complications[27,28]
  - Continued coughing
  - Stent shortening
  - Stent migration
  - Stent fracture
  - Tracheal collapse on either side of the stent (not a true complication)
  - Tracheitis (inflammatory and infectious)
    - Granulation tissue development
- Outcome
  - Clinical improvement seen in 75-90% of cases[28]
  - Perioperative mortality approximately 0-8%
  - Continued coughing is expected
    - Requires long-term antitussive therapy

Liver

Laparoscopic Liver Biopsies

- Potential indications for performing liver biopsies
  - Persistently increased liver enzymes
    - Both alkaline phosphatase and alanine aminotransferase in cats
    - Particularly alanine aminotransferase in dogs
  - Persistent hepatic hyperbilirubinemia
  - Persistently increased serum bile acids (that is not suspected to be related to a macrovascular portosystemic vascular anomaly)
  - Evaluation of hepatic lesions found on diagnostic imaging
  - Unexplained hepatomegaly
  - Evaluation of portal hypertension
  - Evaluation for breed-specific hepatopathies
- Preoperative evaluation
  - Liver enzymes +/- liver function
  - Abdominal imaging
    - Abdominal radiographs

        - Liver size
        - Masses
      - Abdominal ultrasound
        - Intraparenchymal lesions
        - Portal flow
        - Ultrasound-guided aspirate for cytology
    - Coagulation status should be evaluated within 24 hours of the biopsy
      - Complete blood count
      - Clotting times
- Liver biopsy techniques – diagnostic accuracy similar amongst the different techniques
  - Tru-cut biopsy
  - Surgical wedge biopsy
  - Laparoscopic biopsy
    - Minimally invasive, safe, and accurate[29]
- Samples
  - Histopathology
    - Sample from left and right sides of liver
    - At least 2-3 total for histopathology
    - Place in formalin quickly
    - Request staining for copper (in dogs)
  - Copper quantification (dogs)
    - One sample in a plastic container
    - Avoid contact with saline
  - Culture
    - Aerobic and anaerobic
    - Culture of bile is more sensitive than liver[30]

<u>Percutaneous Cholecystectomy</u>

- Performed to obtain bile for culture +/- cytology
- Typically, easily performed using a 22 ga spinal needle
- Can be performed using direct visualization during laparoscopy or via ultrasound guidance

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Endocrinology Hyperadrenocorticism – Part 1

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Hyperadrenocorticism: Diagnostic Tips & Tricks

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"Cushing's syndrome," or hyperadrenocorticism (HAC), refers to the clinical signs associated with the presence of excess glucocorticoids in the body, either from exogenous administration or endogenous production. There are three different forms of hyperadrenocorticism. Iatrogenic hyperadrenocorticism is caused by the exogenous administration of glucocorticoids. "Cushing's disease," or pituitary-dependent hyperadrenocorticism (PDH), refers to excess cortisol production due to a pituitary tumor. Hyperadrenocorticism can also be caused by an adrenal tumor (AT).

Approximately 85% of all naturally occurring HAC is pituitary-dependent. The remaining 15% are caused by adrenal tumors. Of dogs with PDH, about 85% are caused by adenomas arising from the anterior lobe; 15% are caused by adenomas in the intermediate lobe. The majority of dogs with PDH have microadenomas that are not visible to the naked eye. Other dogs have macroadenomas that can be seen with CT or MRI. In addition to HAC, these tumors can cause neurologic signs, but typically not until >10 mm in diameter (~15%).
Dogs with PDH secrete a much larger amount of ACTH than normal dogs. This excess stimulation from ACTH then causes over-secretion of cortisol from BOTH adrenal glands and results in bilateral adrenomegaly.

Dogs with AT usually secrete excessive cortisol from only one adrenal gland. Half of the adrenocortical tumors are adenomas, and the other half are adenocarcinomas. Since the hypothalamus and pituitary gland detect high levels of cortisol in the blood, CRH and ACTH secretion are dramatically decreased. Since the contralateral adrenal gland requires stimulation from ACTH to synthesize cortisol, cortisol secretion from that adrenal gland decreases, and the gland becomes atrophic.

Dogs with iatrogenic hyperadrenocorticism have very low levels of ACTH in their blood due to inhibition from the exogenous glucocorticoid. Chronic ACTH deficiency causes bilateral atrophy of the adrenal glands. As long as the dog is receiving glucocorticoids, it has clinical signs of hyperadrenocorticism, but the adrenal glands are atrophied. If chronic steroid administration is discontinued abruptly, pituitary ACTH production will resume, but the atrophied adrenal cortices may be unable to produce sufficient cortisol in a stressful situation. This results in iatrogenic hypoadrenocorticism.

CLINICAL SIGNS AND CLINICOPATHOLOGIC AND RADIOGRAPHIC ABNORMALITIES

The classic signs of HAC are panting, polyphagia, polydipsia, and polyuria. They also may have recurring skin infections or urinary tract infections. In hindsight, many dogs have also been less active, less likely to play, and less interactive for months preceding diagnosis. Muscle wasting, particularly leading to hindlimb weakness in larger dogs, may also occur.

Testing for HAC is rarely, if ever, indicated in patients that do not have clinical signs. **The vast majority of dogs with HAC do not have clinical signs of illness, such as vomiting, anorexia, or diarrhea.** The exception is dogs with pituitary macroadenomas, or metastatic adenocarcinomas. Unless either of these is suspected, clinically ill dogs should generally not be tested for hyperadrenocorticism. Non-adrenal illness interferes with endocrine testing, and treatment for hyperadrenocorticism is rarely recommended in dogs that are clinically ill.

Physical examination of patients with HAC often reveals the characteristic pot-bellied appearance. Dermatologic changes such as alopecia (or slow hair re-growth), thin skin, pigmentation, comedones, and dermatitis may be present.

Clinicopathologic abnormalities frequently found in dogs with naturally-occurring HAC include: increased ALP, ALT, cholesterol, and glucose (mild unless diabetic—5%); “stress” leukogram (neutrophilia, monocytosis, and lymphopenia); and isosthenuria (USG <1.020). Increased ALP and cholesterol are so common in these patients that it is very unlikely that a patient has HAC if they do not have at least one of these findings.

About 50% of patients have a urinary tract infection at diagnosis of HAC. Because cortisol decreases the inflammatory response and causes isosthenuria, many of these patients will NOT have active sediments. Therefore, a urine culture should be performed in all patients diagnosed with HAC, regardless of whether they have an active sediment.

Radiographs in dogs with HAC usually reveal hepatomegaly. An adrenal tumor may be seen, if present. Half of all adrenal tumors are mineralized. Mineralization does NOT predict whether a tumor is an adenoma or adenocarcinoma. Thoracic radiographs may reveal metastasis from a tumor. Abdominal ultrasound may reveal bilaterally enlarged adrenal glands (PDH) or one large adrenal gland (AT) and a very small contralateral gland. Metastasis may also be found with ultrasound (most frequently in the liver).

DEFINITIVE DIAGNOSIS

Diagnosis of HAC requires compatible clinical signs, clinicopathologic abnormalities, and specific endocrine tests. Specific tests for the diagnosis of HAC can be divided into SCREENING and DIFFERENTIATING tests. Screening tests, which help to identify patients with HAC, include the ACTH-stimulation test, low dose dexamethasone suppression test (LDDS), and urine cortisol:creatinine ratio (UCCR). Differentiating tests determine whether a patient with HAC has PDH or an AT. These include the LDDS, HDDS, endogenous ACTH, abdominal ultrasound, and the MRI and CT.

All of the screening and differentiating tests have advantages and disadvantages. However, the LDDS is preferred for most cases seen in general practice because it is very sensitive and can also be used for differentiation.

Screening Tests

While the UCCR is a very sensitive test (up to 99%), it is not very specific and may be positive in patients with other disease. This test is often useful to rule-out HAC. A negative test almost always rules-out the diagnosis of HAC. However, a positive test result requires confirmation with another screening test. The UCCR is most useful in patients in which there is a low index of suspicion for the disease.

The LDDS is a very useful test. It is very sensitive (~95%), and more specific than the UCCR (but less so than the ACTH stimulation test). Briefly, a serum pre-sample (0 hr) is collected from the patient immediately prior to administration of 0.01 mg/kg dexamethasone, IV. Another sample is drawn at 4 hrs and another sample at 8 hours. Note that if dexamethasone sodium phosphate is used, even though the bottle lists the concentration as 4 mg/mL, only 3 mg/mL is actually dexamethasone.

For DIAGNOSIS, not differentiation, of HAC, the clinician need only look at the 0 hr and the 8 hr samples. Remember—the dog must first be diagnosed with HAC before its etiology is determined. The 4-hr sample is not used for diagnosis. Although reference values vary with the laboratory, a dog is considered to have a normal response if the 8 hr cortisol sample is <1.4 µg/dL. A cortisol concentration greater than 1.4 ug/dL is consistent with the diagnosis of hyperadrenocorticism.

The ACTH stimulation test is the least sensitive, but most specific, of the three tests. Sensitivities as low as 60% have been reported. The test is less likely than the LDDS or UCCR to have a false positive result. The recommended protocol requires the collection of a pre-ACTH serum sample, prior to administration of 5 µg/kg (up to 250 µg) of synthetic cosyntropin, IV or IM. A post-serum sample is then collected 1 hour later. Cortisol values of <17 µg/dL are NOT diagnostic for HAC; values from 17-22 µg/dL are in the grey zone; and values >22 µg/dL are consistent with the diagnosis of HAC.

Differentiation Tests

After diagnosing a patient with HAC with one of the above methods, one must determine whether the HAC is PDH or caused by an AT. This information is optimal for proper treatment of the disease. It is NOT possible to completely rule out a pituitary tumor without imaging of the abdomen and/or brain. However, it IS possible to rule it in.

The LDDS is most frequently used because of its ability to screen and differentiate. After the HAC has been diagnosed with an 8 hr sample >1.4 µg/dL, several criteria for differentiation can be evaluated. The LDDS is consistent with PDH if: the 4 hr cortisol sample is <1.4 µg/dL; the 4 hr cortisol sample is <1/2 baseline; or the 8 hr cortisol sample is <1/2 baseline. It is important to realize that some patients with PDH do not suppress at either time point. In fact, over half of the dogs that don't suppress actually have PDH!

The HDDS is very similar to the LDDS and has a slightly increased chance of picking up a dog with PDH. The protocol is the same as the LDDS, except that the dexamethasone dose is 0.1 mg/kg, IV.

The HDDS is consistent with PDH if: the 4 hr OR 8 hr cortisol sample is <1.4 µg/dL; or the 4 hr OR 8 hr cortisol sample is <1/2 baseline. Again, all dogs with PDH do NOT suppress with the HDDS. Approximately 50% of dogs that do not suppress have PDH.

Although clinically useful, the endogenous ACTH concentration is more difficult to obtain due to the lability of the hormone. A blood sample must be drawn into a plastic EDTA tube and centrifuged immediately. The plasma should be separated and frozen immediately, until reaching the diagnostic lab. Alternatively, apoprotinin can be used as a preservative. Intuitively, high ACTH levels are consistent with PDH, and very low levels are consistent with ADH. Unfortunately, since ACTH is secreted episodically by the pituitary, it is possible for a dog with PDH to have a low ACTH value. So, although a high value is diagnostic for PDH, a low value does NOT rule it out.

Imaging studies are often helpful in the differentiation of PDH from AT. An abdominal ultrasound that reveals bilaterally enlarged adrenal glands is consistent with a diagnosis of PDH. If there is one very large adrenal gland and a very small contralateral gland, the dog has an AT.

MRI and CT can help diagnose PDH and give an indication of how large the tumor is. Tumors greater that 10 mm may cause neurologic signs (dullness, altered mental status, anorexia, etc.). Brain imaging will differentiate a macroadenoma from a microadenoma, and help identify patients that may benefit from radiation therapy. The indications for an MRI or CT are: 1. Evaluation of a neurologic dog with HAC; 2. Discriminating PDH from AT (if macroadenoma is present); 3. Identification of patients for radiation therapy. If PDH has been diagnosed by other methods and the dog does not have neurologic signs, imaging of the brain is only indicated if the owner is willing to pursue radiation therapy if a large macroadenoma is present.

IATROGENIC HAC

A dog with iatrogenic HAC generally shows clinical signs of HAC while receiving long-term glucocorticoids. However, if the steroid is suddenly discontinued, the atrophied adrenal glands will be unable to respond to stress, and clinical signs of hypoadrenocorticism may occur due to cortisol deficiency. Since exogenous glucocorticoids suppress ACTH secretion and may cause adrenal atrophy, an ACTH stimulation test is used to identify a patient with iatrogenic HAC. The test is performed as described above, except that the corticotrophin is given IV. A dog with iatrogenic HAC should have a flat-line response, generally with both baseline and 1 hr post-stimulation values of <1 µg/dL.

It is important to note that even short courses of glucocorticoids may inhibit the adrenal response to ACTH for up to a month or more. These patients often have decreased, but not baseline, responses (post ~2 µg/dL – 5 µg/dL). Usually, careful questioning of the owner will reveal steroid administration, which may include topical steroids. Additionally, some steroids, such as prednisone, can interfere with the cortisol assay and falsely elevate the value. Thus, there should be at least a 24 hr “washout” period after administration of short-acting steroids, and longer for longer-acting steroids.

SMALL ANIMAL PROCEEDINGS

June 5–7, 2022

Endocrinology Hyperadrenocorticism – Part 2

Dr. Patty Lathan, Mississippi State University

UPDATE ON MONITORING DOGS RECEIVING TRILOSTANE THERAPY

Patty Lathan, VMD, MS, DACVIM
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Trilostane is an enzyme inhibitor that decreases production of cortisol, and, to a lesser extent, aldosterone and other steroids. Based on its mechanism of action, it should not cause adrenal necrosis in the same way as mitotane, but trilostane can still lead to Addisonian crisis due to hypocortisolemia. Additionally, trilostane has been reported to cause idiosyncratic adrenal necrosis in dogs (resulting in both glucocorticoid and mineralocorticoid deficiency), although this is rare. Survival times for PDH patients treated with trilostane and mitotane are similar (approximately 2 years) (Barker EN 2005). However, in my experience, if a veterinarian has little experience using either mitotane or trilostane, trilostane is easier to learn to use.

There is no induction phase involved with the administration of trilostane. Dogs are started on 2-3 mg/kg totally daily dose (SID or divided and given BID), and seen for a recheck 10-14 days later. During rechecks, it is important to assess the clinical signs of the patient based on the owners' assessment of how much the dog is drinking, urinating, and eating. Any lethargy, diarrhea, vomiting, or refusal to eat should also be noted. Although the ACTH stimulation test has been used to assess treatment efficacy for the past two decades, recent evidence suggests that a pre-pill cortisol concentration correlates with clinical signs at least as well as an ACTH stimulation test. However, ACTH stimulation tests are still sometimes necessary, particularly if the patient is showing any signs of illness consistent with Addison's disease.

The pre-pill cortisol is measured from blood taken just prior to the time that the morning pill is administered. If the patient is well-controlled and the pre-pill cortisol is >1.4-2 ug/dL, continuing on the current dose is probably safe. However, if the value is <1.4-2 ug/dL, or the dog is showing any signs of illness, an ACTH stimulation test is indicated. If the patient is not clinically controlled (still polyuric, polydipsic,and/or polyphagic), and the pre-pill cortisol is >3.0 ug/dL, it is likely safe to increase the dose by 10-20% (or split to BID), and recheck in 2-4 weeks. If the pre-pill cortisol is <3.0 ug/dL, I recommend performing an ACTH stimulation test prior to increasing the dose.

An ACTH stimulation test can be used either instead of using pre-pill cortisol monitoring, or in addition to pre-pill cortisol monitoring. The test should be started 3-4 hours post-pill to assess cortisol levels at peak inhibition. Thus, the pill should be given in the morning if the dog is on SID dosing. The target post-stimulation cortisol concentration for a well-controlled dog is 2-6 µg/dL, but this MUST be interpreted in light of clinical signs. This range is flexible, depending on clinical response; a dog that has been on trilostane for 6 months and is doing well with a post-stimulation value of 1.6 µg/dL may be fine, whereas a dog that has GI signs with a post-stimulation value of 2.1 µg/dL may need his dose decreased. Similar holds true at the upper end of the range.

Of note, the effects of a given dose of trilostane often increase even after the first two weeks of therapy. For example, if a dog is on 30 mg once daily and has a post-ACTH stimulation cortisol value of 9 ug/dL at 14 days, this may decrease to 5.5 ug/dL two weeks later, even if the dog is on the same dose. Thus, if the 14 day post-stim cortisol is <10 ug/dL following initiation of trilostane, I usually wait to increase the dose until after the next ACTH stimulation test two weeks later. Depending on those ACTH stim results, the trilostane dose may be increased or decreased by 20-50%.

Each time the trilostane dose is changed, a pre-pill cortisol and/or ACTH stimulation test should be run about 10-14 days later. After the appropriate dose is determined, the dog should return for monitoring (assessment of clinical signs AND pre-pill cortisol +/- ACTH stimulation test) two weeks later, 3 months later, and then every 3-6 months. The dose of trilostane may need to be increased, as patients seem to get more resistant to it with time. Additionally, adrenocortical necrosis is possible at any point during therapy. It MUST be stressed that owners still need to be cautioned that this drug can also lead to disastrous consequences if appropriate monitoring is not followed.

Dogs seem to get regulated more quickly on twice-daily dosing. Some dogs aren't as well-controlled on once-daily trilostane dosing, likely because the duration of efficacy of trilostane is variable, from 10-18 hrs. In these dogs, the dose may be divided and given BID. Dogs on the BID protocol generally need a lower total daily dose than those on SID dosing, and their clinical signs are often better controlled. Because of the increased efficacy of trilostane based on ACTH stimulation tests, some authors prefer to start patients on BID dosing (1-2 mg/kg BID).

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SMALL ANIMAL PROCEEDINGS

June 5-7, 2022

Endocrinology – Addison's

Dr. Patty Lathan, Mississippi State University

Addison's Update: A Case-Based Approach

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Hypoadrenocorticism ("Addison's disease") is an uncommon disease in dogs. However, because of the potential for acute death in dogs with severe acid/base and electrolyte abnormalities, and the excellent prognosis with treatment, prompt diagnosis is crucial.

BACKGROUND

The adrenal cortex is divided into 3 different layers. In order of outermost to innermost, they are the *zona glomerulosa*, *zona fasciculata*, and *zona reticularis*. Only the *zona glomerulosa* can make aldosterone, while the *z. fasciculata* and *reticularis* are responsible for the production of cortisol. Cortisol's function is primarily catabolic, in that it stimulates the breakdown of fat, muscle, and glycogen for use in gluconeogenesis. It's one of the four "anti-insulin" hormones that protect the body from hypoglycemia.

Cortisol secretion is regulated by the hypothalamic-pituitary-adrenal axis (HPAA). Physiologic, psychologic, and/or emotional stress initially stimulates the hypothalamus to secrete CRH (corticotrophin releasing hormone). CRH then stimulates the pituitary gland to release adrenocorticotropic hormone (ACTH) into systemic circulation. When ACTH reaches the adrenal cortex, it stimulates the synthesis of cortisol.

As with other endocrine axes, the synthesis of cortisol is controlled by feedback inhibition. Cortisol itself inhibits further release of CRH and ACTH. Thus, when an abundance of cortisol is present in the body, that cortisol prevents additional stimulation of cortisol secretion in normal animals.

Aldosterone is a mineralocorticoid that stimulates the resorption of sodium, chloride, and water; and excretion of potassium, from the distal renal tubules. A deficiency in aldosterone can lead to hyponatremia, hypochloremia, hypovolemia, and hyperkalemia. Secretion of aldosterone is controlled by the renin-angiotensin-aldosterone (RAS) system. Note that physiologic doses of ACTH do NOT appear to play a significant role in the regulation of aldosterone synthesis; therefore, pituitary pathology resulting in ACTH deficiency should not result in aldosterone deficiency.

ETIOLOGY

In dogs, Addison's is most commonly caused by adrenocortical failure, usually secondary to immune-mediated destruction of >90% of the adrenal cortex. Most patients exhibit signs of both cortisol and aldosterone deficiency. Neoplastic, infectious, and inflammatory infiltration of both adrenal cortices may also result in combined deficiency. Secondary hypoadrenocorticism due to ACTH deficiency results in isolated cortisol deficiency. Iatrogenic administration of exogenous glucocorticoids is the most common cause of secondary hypoadrenocorticism; however, pituitary neoplasia or trauma, in addition to idiopathic causes, may also result in secondary hypoadrenocorticism.

In patients with “atypical” hypoadrenocorticism clinical signs of cortisol deficiency occur without concurrent electrolyte abnormalities. The etiology of atypical Addison’s is unclear; ACTH deficiency has been ruled out in most cases. It may be the result of partial immune-mediated destruction of the adrenal cortex, sparing the zona glomerulosa. Alternatively, some dogs with aldosterone deficiency may compensate via an unknown mechanism. Although some have speculated that atypical hypoadrenocorticism is simply an early manifestation of “typical” hypoadrenocorticism, many patients never lose their ability to secrete aldosterone.

CLINICAL PRESENTATION AND CLINICOPATHOLOGIC ABNORMALITIES

Clinical presentation of hypoadrenocortical patients varies from patients with chronic “failure to thrive” (ADR) and/or gastrointestinal signs (anorexia, vomiting, diarrhea, melena, etc.), to patients that present acutely in hypovolemic shock. Both groups of patients may have a history of improvement with fluid administration and/or glucocorticoid therapy.

Physical examination findings can also vary from almost normal to hypovolemic shock. Hyponatremia and hyperkalemia are the classic laboratory findings in dogs. However, these findings may be absent early in the disease process, and in dogs with atypical hypoadrenocorticism. Additionally, atypical Addisonians rarely present in hypovolemic shock; however, excessive gastrointestinal blood loss can lead to hypovolemic shock in these patients.

Regurgitation may be seen in rare Addisonian patients with megaesophagus, and seizures have also been reported secondary to hypoglycemia. Polyuria and polydipsia occur infrequently in dogs with hypoadrenocorticism; the mechanism is unknown.

Additional laboratory abnormalities may include azotemia, hypoglycemia, hypochloremia, hypocholesterolemia, hypercalcemia and metabolic acidosis (decreased tCO_2/bicarbonate). Hypoadrenocorticism should be considered in patients that present for signs of hypoglycemia (such as seizures) and hypercalcemia. Because most patients also have a specific gravity <1.030, azotemic patients can be incorrectly diagnosed with primary renal failure. In these cases, the patient’s history and rapid response to fluid therapy should increase suspicion of hypoadrenocorticism.

Patients exposed to cortisol often exhibit neutrophilia and lymphopenia (“stress leukogram”). In the absence of cortisol, such as with hypoadrenocorticism, patients may be predicted to have neutropenia, lymphocytosis, and eosinophilia. In fact, these specific changes don’t occur very frequently in Addisonian patients. However, a number of Addisonians do have a “lack of a stress leukogram,” meaning that they do not have neutrophilia or lymphopenia. In a clinically ill patient, the findings of normal neutrophil and/or lymphocyte counts, with or without eosinophilia, are unexpected, and may raise suspicion of hypoadrenocorticism.

ADDITIONAL DIAGOSTICS

In cases of moderate to severe hyperkalemia, an ECG may reveal spiked T-waves, absent p-waves, increased P-R interval, and/or bradycardia. Other basic diagnostic findings in hypoadrenocortical dogs

are non-specific. Thoracic radiographs may reveal microcardia (consistent with hypovolemia) or megaesophagus. Abdominal ultrasound may reveal small adrenal glands.

DEFINITIVE DIAGNOSIS

Definitive diagnosis relies on results of an ACTH-stimulation test in both typical and atypical Addisonians. Post-stimulation cortisol samples of <2 µg/dL are consistent with hypoadrenocorticism, although rare patients may have stim results between 2 and 3 µg/dL. Steroids given days prior to the test may blunt the response, and it is not uncommon for a dog with a history of recent glucocorticoid administration to have a post-stimulation cortisol of 2.5 – 5.0 µg/dL. Most synthetic glucocorticoids (including prednisone and methylprednisolone) will interfere with the cortisol assay itself, and may cause a falsely elevated cortisol result. However, dexamethasone does not interfere with the cortisol assay, and may be given prior to or during the ACTH stimulation test, if necessary.

BASELINE CORTISOL—FOR RULE-OUT PURPOSES ONLY!

Although definitive diagnosis of Addison's requires an ACTH stimulation test, the disease can be RULED-OUT by checking baseline cortisol values. If the baseline cortisol is >2 µg/dL, the dog does not have hypoadrenocorticism (there are exceptionally RARE cases that could have a value from 2-3 ug/dL). If the baseline cortisol is <2ug/dL, an ACTH stimulation test MUST be run to confirm the diagnosis. The baseline cortisol is most useful in patients without electrolyte abnormalities that may be suspected of atypical hypoadrenocorticism because of chronic GI signs. Since it does not require the purchase of synthetic ACTH, it is much less expensive that the ACTH stimulation test.

TREATMENT—TYPICAL HYPOADRENOCORTICISM

Treatment of hypoadrenocorticism depends on the presentation of the patient. If they present in hypovolemic shock ("Addisonian crisis"), diagnosis is usually unknown initially, and treatment is generally similar to that for any patient in hypovolemic shock. The first priorities in stabilizing a patient in Addisonian crisis are to correct the hypovolemia and the hyperkalemia, since these conditions are most likely to be fatal if not treated immediately. Although 0.9% NaCl has been recommended because of its sodium content and lack of potassium, isotonic crystalloids such as Normosol-R and Lactated Ringer's Solution may also be used—they are generally more alkalinizing, they have minimal amounts of potassium, and their lower sodium contents are actually helpful in patients with severe hyponatremia (<120 mEq/L). Hypoglycemic patients should be treated with dextrose.

If the dog is moderately hyperkalemic, the hyperkalemia will likely be corrected with fluid therapy alone. However, if the hyperkalemia is severe (>8.5 mEq/L) or causing ECG changes, additional therapy may be warranted. A 10% solution of calcium gluconate (0.5-1.5 mL/kg, or 2 to 10 mL/dog) may be administered intravenously over 10 to 15 minutes while monitoring for ECG changes associated with hypercalcemia. Although the effect is almost immediate, it lasts for only about 10 to 30 minutes. This treatment is cardioprotective and does NOT lower the potassium concentration. Simultaneous intravenous administration of dextrose (1 g/unit of insulin) and regular (R) insulin (0.2 U/kg) will decrease potassium levels within 15 to 30 minutes. A 5% dextrose solution in a balanced electrolyte solution (Norm R or LRS) should be administered after insulin treatment to alleviate hypoglycemia.

Glucocorticoids should be given to a patient during the crisis. Dexamethasone, 0.2 mg/kg, may be given initially. Although this dose is lower than recommended in some drug resources, it is equivalent to approximately 1.5 mg/kg of prednisone and is more than adequate. This dose is often given twice the first day, and then cut in half for the next two days. As soon as the patient is eating, he may be given oral prednisone. While in the hospital, the patient needs more than the normal physiologic dose (~0.2 mg/kg/day); approximately 1 mg/kg/day is commonly used. The dog may go home on an increased dose of 0.5 mg/kg/day for a couple of days, and then be tapered to around 0.1 – 0.3 mg/kg/day. This dose is adjusted based on the clinical signs of the dog (activity level, appetite, gastrointestinal signs), combined with the avoidance of side effects from the prednisone, such as PU/PD. The author frequently tapers to doses lower than 0.1 mg/kg (such as 0.05 mg/kg), especially in large dogs, based on clinical signs and side effects. Note that once an ACTH stimulation test confirms naturally occurring hypoadrenocorticism, it does not need to be repeated and is not used in monitoring prednisone dose.

Following confirmation of hypoadrenocorticism, the dog should also be started on a mineralocorticoid replacement. The author's preference is desoxycorticosterone pivalate (DOCP). The label dose is 2.2 mg/kg, q25-28d, but recent studies and experience show that lower doses may be acceptable, particularly in large dogs. I usually start no higher than 1.5 mg/kg. Although the first dose may be given IM in case dehydration impedes SQ absorption, subsequent doses can usually be given SQ. Electrolyte values should be checked 14 days after injection to assess the dose, and immediately prior the next injection (25-28d) to assess duration of activity. Dose and frequency should then be modified based on these electrolyte values. Electrolytes should be rechecked every 3-6 months following dose stabilization.

Two FDA-approved DOCP formulations are available—Percorten-V® (Elanco) and Zycortal® (Dechra). The only differences between the two formulations are a different preservative is used in each, and that Zycortal® is labeled for SQ administration, while Percorten-V® is labeled for IM administration. In 1995, a study (McCaben, et al, *JAAHA*) established that Percorten-V® may be administered SQ, and there's no reason to believe that Zycortal® could not be administered IM, if necessary.

It is IMPERATIVE that owners be cautioned not to try to space out or skip DOCP injections without the advice of a veterinarian for financial reasons. This almost always leads to an Addisonian crisis eventually, which risks the patient's life and increases overall cost of treatment. Alternatively, fludrocortisone may be used as a mineralocorticoid supplement. It is oral and initially given at 0.02 mg/kg/d, It also has some corticosteroid activity. However, patients should be stabilized (ie, consistently normal electrolytes during rechecks) using a combination of fludrocortisone and prednisone. Then the prednisone dose can be tapered to the lowest effective dose. Approximately 50% of Addisonian dogs managed with fludrocortisone do not require long-term prednisone supplementation.

Management of a chronic Addisonian involves the administration of prednisone and a mineralocorticoid, as described above. Additional glucocorticoids, 2-3 times the normal dose, should be given when the

dog is stressed, such as prior to veterinary visits (even for DOCP injections), or when there are visitors to the home.

TREATMENT—ATYPICAL HYPOADRENOCORTICISM

Treatment of atypical hypoadrenocorticism includes glucocorticoid replacement and supportive therapy. Depending on the presentation, patients with more chronic signs may be managed at home, whereas patients with more significant gastrointestinal signs will need hospitalization. The physiologic dose of prednisone is thought to be 0.1- 0.25 mg/kg, and stressed patients need approximately 2 times this dose. At diagnosis, I typically start these patients at about 1 mg/kg of prednisone per day to account for the stress of illness and hospitalization (or hospital visits). (If parenteral therapy is necessary, I use 0.10-0.15 mg/kg dexamethasone, as it has 7-8 times the glucocorticoid activity as prednisone.) This dose is slowly decreased so that the patient is receiving the physiologic dose of prednisone within a few days of returning home. Dose is adjusted based on the clinical signs. If the dog becomes PU/PD, the dose is decreased. If gastrointestinal signs increase, or the dog is lethargic overall, the dose is increased. Additionally, the prednisone dose must be increased if the patient experiences stress—such as a vet visit, houseguests, increased exercise (such as hunting), or unrelated illness.

Supportive therapy may include intravenous fluids, gastroprotectants, blood transfusion (if GI blood loss is severe), dextrose administration, etc., depending on the clinical presentation of the patient.

PROGNOSIS

The prognosis for good quality of life is excellent with prompt treatment of typical hypoadrenocorticism. Even hunting dogs can return to normal activity (with adjustment of prednisone dose), and patients have a normal life expectancy. Dogs with atypical hypoadrenocorticism also have a great prognosis, and some (approximately 10%, based on experience) develop mineralocorticoid deficiency following initial diagnosis. Thus, measurement of electrolytes one week, 1 month, and then every 3-6 months following diagnosis is recommended.

SMALL ANIMAL PROCEEDINGS

June 5-7, 2022

What Is "Safe" Anesthetic Monitoring?

Dr. Nathaniel Kapaldo, Kansas State University

Evidence And Rationale For 'Safe' Monitoring Practices in Anesthetized Patients

Nathaniel Kapaldo, DVM, MPH, Diplo. ACVAA; Assistant Professor of Anesthesiology at Kansas State University's Veterinary Health Center

Historically an emphasis in the management of anesthetized veterinary patients has been on the reduction of perioperative mortality. While this remains a primary focus, the discipline of anesthesiology continues to develop; and so, standards of care for anesthetized veterinary patients do the same. Pair the latter with expanding client expectations, a shift in this paradigm from simply reducing mortality to a concomitant reduction in perioperative mortality and morbidity must be a focus. General anesthesia effectively blunts brainstem function and thus disturbs physiologic homeostasis. It is thus the anesthetist's goal to as closely maintain normal body system function as possible, advocating for each patient's wellbeing in the peri-/intraoperative period. In this short seminar we will review evidence for monitoring practices from both human and veterinary anesthesia literature. Additionally, we will go over specific monitoring practices and equipment while briefly discussing individualizing patient monitoring. This will unfortunately not be a comprehensive review of patient monitoring but will aim to refresh your practice's approach to patient management. All slides and material will be available to attendees following presentation.

Notes

SMALL ANIMAL PROCEEDINGS

June 5-7, 2022

Blood Pressure Matters: A Practical Approach To Management

Dr. Nathaniel Kapaldo, Kansas State University

A Pragmatic Approach To Blood Pressure Management

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Ensuring adequate circulatory function during general anesthesia is a recommended standard of care by the American College of Veterinary Anesthesia and Analgesia as well as numerous other veterinary organizations. In people, the ability to monitor and intervene for adequate/inadequate circulatory function during the peri-/intraoperative period is a requirement. In this short seminar we will re-visit the cardiovascular physiology that underlies the importance of monitoring circulatory function, and blood pressure, in anesthetized patients. We will review the evidence to support monitoring this parameter and specific methods to do so. We will also discuss patient specific monitoring goals and intervention strategies in a pragmatic manner. Additionally, aiming to make individual patient management a realistic and achievable goal. All slides and material will be available to attendees following presentation.

Notes

SMALL ANIMAL PROCEEDINGS

June 5–7, 2022

The Link Between Human and Animal Abuse

Dr. Abbie Viscardi, Kansas State University

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SMALL ANIMAL PROCEEDINGS

June 5–7, 2022

Is Artificial Intelligence Stealing My Job?

Dr. Nicolette Cassel, Kansas State University

Is Artificial intelligence stealing my job? A review of AI as it pertains to veterinary medicine

June Conference 2022
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Introduction:

Artificial intelligence (AI) is not a novel concept, and we encounter AI in our daily lives without even being aware of its influence. It has been employed in the field of human medicine since the 1990's and currently there are over 300 AI enabled devices approved for use by the Food and Drug Administration – the majority of these designed for use in radiology. Whilst veterinary medicine has definitely lagged behind our human medicine peers, this field is rapidly advancing and coming to a practice near you, if not already there!

What is artificial intelligence? AI is the ability of machines (computer systems) to do the work of humans. These often include but are not limited to, the mundane, repetitive and labor intensive tasks. A lot of AI goes on in the background of many businesses in order to allow them to function more efficiently. Machine learning (ML) is a sub-field of AI, in which a computer creates its own decision making parameters, learning from data input rather than relying on preset, manual programming. Artificial intelligence and machine learning is a technology that is very well suited to the field of diagnostic imaging and has the ability to enhance the efficiency and accuracy of radiologists and clinicians.

You are not immune to the influence of AI on your life outside of your profession. Ever feel like "big brother" is watching you, when something you googled yesterday suddenly is all you're your social media platforms? Artificial intelligence is what drives search engines to recommend products based on previous searches. Suri, Alexa and Bixby are all perturbations of the AI world. Prediction of gas prices, advanced weather models and predictions of housing prices are all thanks to AI. Big brother is indeed watching you!

The process of artificial intelligence and machine learning.

All good AI systems start with great data collection. Just as in a good scientific study, deciding what the inclusion and exclusion criteria are, so to it is vital to decide on what data is collected and how this data is explored, cleaned and labelled is key to a valuable AI experience. Data cleaning refers to deciding what data can be used and if there is missing data, can this data either be augmented and missing values added, or should it be removed. Any deficits to the data collection process will result in a AI system that is biased and does not perform well. Once data is collected and cleaned it needs to be labelled. Data can be labelled objectively, based on human interpretation or a blended approach. If data is labelled by human interpretation, the

best practice is to have several opinions from trained specialists in that field in order to come to a quorum assessment.
Data collection is followed by a training phase, wherein the computer learns to perform a task. This is a cyclical process of assessment, adjustment and re-analysis. Thereafter a performance assessment phase follows, where the algorithm is tested on a novel validation set of data. Once the process has gone through extensive repetitive training, the algorithm is presented with a set of new novel data, not seen by the algorithm before and a test phase is performed.

Types of machine learning

Depending on how the system is trained to handle the data will depict the method of "learning" the machine undergoes. Machine learning can be divided into supervised, unsupervised and reinforcement learning categories. Supervised learning is most often employed in the veterinary field of AI where ground truth data is used to train the algorithm. Ground truth data can be a reference standard (normal reference range for creatinine values), cytology or histopathology report or radiologists assessment. The input data and quality thereof in such a training algorithm is thus crucial. In unsupervised learning, the algorithm is not provided with ground truth data and makes its own decisions based on pattern recognition during training. Another type of ML is deep learning, a variety of learning that involves neural networks (NN). Neural networks are algorithms that resemble the biological brain. A series of mathematical decision making points, termed nodes, are interconnected with neighboring nodes in sequential layers. Neural networks are named for its similarity to the action potentials across neurons in the brain. Each node can pass its computational output to one or many nodes within the same layer or an adjacent layer. The strength with which a node can influence its neighbors can be modified to alter the eventual decision making that emerges. These systems are continually refined and reinforced throughout the training process before and during the validation and testing phases of product development.

Possible deficits and pitfalls to machine learning

Several deficits are identified in machine learning including bias, underfitting and overfitting. Largely these pitfalls all relate back to a shortfall in the data acquisition and training phase, thereby highlighting the importance of data acquisition in the training of AI algorithms. Statistical bias is encountered in most scientific research and AI algorithms are not immune to this. Factors such as low prevalence of disease, atypical disease processes and selection bias can result and exacerbate selection bias. One crucial example is when asking the algorithm to identify one single change in a body cavity (such pleural effusion) when in reality, other changes of equal or greater diagnostic importance (free gas or a mass) can accompany the change and be unreported by the algorithm. This can result in over estimation of the system. Overfitting and underfitting refer to either over training or undertraining the algorithm, such that the algorithm is either provided with too much detail or too little detail in training and thereby performs poorly when tested against novel data.

Machine learning as it applies to the veterinary field and diagnostic imaging

In recent years, ML has been developed extensively to perform quantitative analysis, such as measuring mass dimensions or performing more intricate algorithmic textural analysis. This has

resulted in the emergence of a complex field of study, termed radiomics. Textural analysis is a radiomic method of machine learning which analyses the differences in pixel intensity and distribution in a given region of interest (tumor mass). This field of science is currently undergoing an explosion of research in several medical fields and there is no end in sight for the capabilities this science has to date.

In veterinary medicine algorithms can be trained to improve workflow management, aid in image pre and post processing and computer-aided detection and diagnosis of disease to name but a few examples. Both computer aided detection and diagnosis can be utilized in parallel with a human reader in order to potentially improve reading efficiency and accuracy. A brief review of the literature to date on AI and ML in the veterinary fraternity will be covered during this presentation. The reported studies have a broad reach across the veterinary spectrum from teat scoring, meat scoring, lameness detection, behavioral recognition and growth evaluation in production animals, to textural analysis in tissue and cytological samples in the pathology world. AI has been applied in the equine fraternity to predict the need for surgery and survivability in colicking horses and in clinical small animal practice some projects have compared multiple NN to classify the severity of canine ulcerative keratitis based on corneal photographs. Artificial intelligence is already used extensively in practice management to convert medical records to digital documents and to search digital documents for key words or phrases – the world of electronic medical records employs AI extensively.

In the imaging world, there are studies (that will be reviewed) in musculoskeletal imaging, thoracic, abdominal and the central nervous system.

Commercial systems available for radiographic interpretation

There are currently several commercial AI systems for radiographic interpretation available for use by you; the practitioner. Some, but not all, of these systems are or have undergone third party testing across diverse data sets and the results are variable. Two studies represent validation of the commercial platform, though each focus on detection of a single condition. This can open the door allows for significant bias and underfitting in real world clinical data. Additional rigorous and comprehensive, third party testing across a diverse data set is still necessary as many of these platforms are in their infancy and mandatory disclosure of internal performance information by AI companies, similar to other diagnostic assays, would be highly valuable for veterinarians seeking to evaluate these products for clinical use. Until such a time that sufficient data is gathered, these systems cannot be assumed to operate within the non-commercial applications reported in the literature. Clinical implementation of AI based image interpretation technology has definitely preceded many of the reviewed publications and claimed capabilities of these systems are being scaled larger than anything reported in the peer review papers. This speaks volumes for the demand for such systems and platforms in clinical practice and is incredibly exciting for anyone who is interested, invested or involved. However, it does raise some questions and concerns currently on transparency, reproducibility and accuracy of the employed algorithms.

Conclusion

Personally, I have encountered a range of reactions to AI amongst veterinarians; both general practitioners and specialists in the imaging field and elsewhere. These reactions range from

enthusiasm to disinterest, confusion and fear, mainly at the fear of potential loss of employment or productivity due to AI.
Together with a group of bright young minds at the radiology department at K-state, we have extensively peer reviewed AI in veterinary imaging and we are of the opinion that AI based image interpretation and quality assurance shows great promise as a tool to augment the efficiency and accuracy of radiologists, other specialists and general practitioners and cannot currently replace the capabilities of an expert radiologist. We do not believe there is a looming unemployment crisis in the field of veterinary radiology but we do feel that as radiologist of the future we need to embrace and familiarize ourselves with the modality of AI and ML and equip ourselves with the necessary skills to work alongside AI. We would encourage you, as practitioners, to do the same!

References:

Available upon request

Acknowledgements:

Dr. Erin Hennessey and Dr. Matt Difazio are bright young minds and current 3rd (EH) and 2nd (MD) radiology residents with a keen interest in AI and were part of a collaborative group at Kansas State University reviewing AI in veterinary medicine.
The content of this paper will be published in a future review paper on AI in the veterinary imaging field.

SMALL ANIMAL PROCEEDINGS

June 5–7, 2022

Heart or Lungs? Surgical Abdomen or Not?

Dr. Nicolette Cassel, Kansas State University

Heart or Lungs? Surgical Abdomen or Not?

Dr. Nicolette Cassel, Kansas State University College of Veterinary Medicine

Are these not two questions you are faced with as a small animal practitioner more often than not? The coughing cat; is it asthma, chronic bronchitis or something else? The coughing dog; does the patient need furosemide or antibiotics? And what about those small intestines…is this an obstructed pattern and should I take him to surgery or should I give the dog another 12 – 24 hours of conservative management. This presentation will be a case based presentation highlighting the radiographic features that help us as diagnosticians make those critical decisions.

Notes:

SMALL ANIMAL PROCEEDINGS

June 5–7, 2022

Guess the Foreign Body

Dr. Nicolette Cassel, Kansas State University

Guess the Foreign Body

Dr. Nicolette Cassel, Kansas State University College of Veterinary Medicine

This will be a more lighthearted film reading session where audience participation is encouraged! Congress attendees will be given the opportunity to review the radiographs of obstructed patients in advance and be asked to guess the foreign body. Whilst the aim is to end the radiology session in a lighthearted manner, it will also highlight the fact that some foreign bodies are not only foreign, but they can also be downright invisible!!!
Notes:

SMALL ANIMAL PROCEEDINGS

June 5–7, 2022

Keeping Pandemic Pets in the Home

Dr. Abbie Viscardi, Kansas State University

Notes