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9th Indian VETopia - 2024

28TH TO 30TH NOV 2024

Venue :
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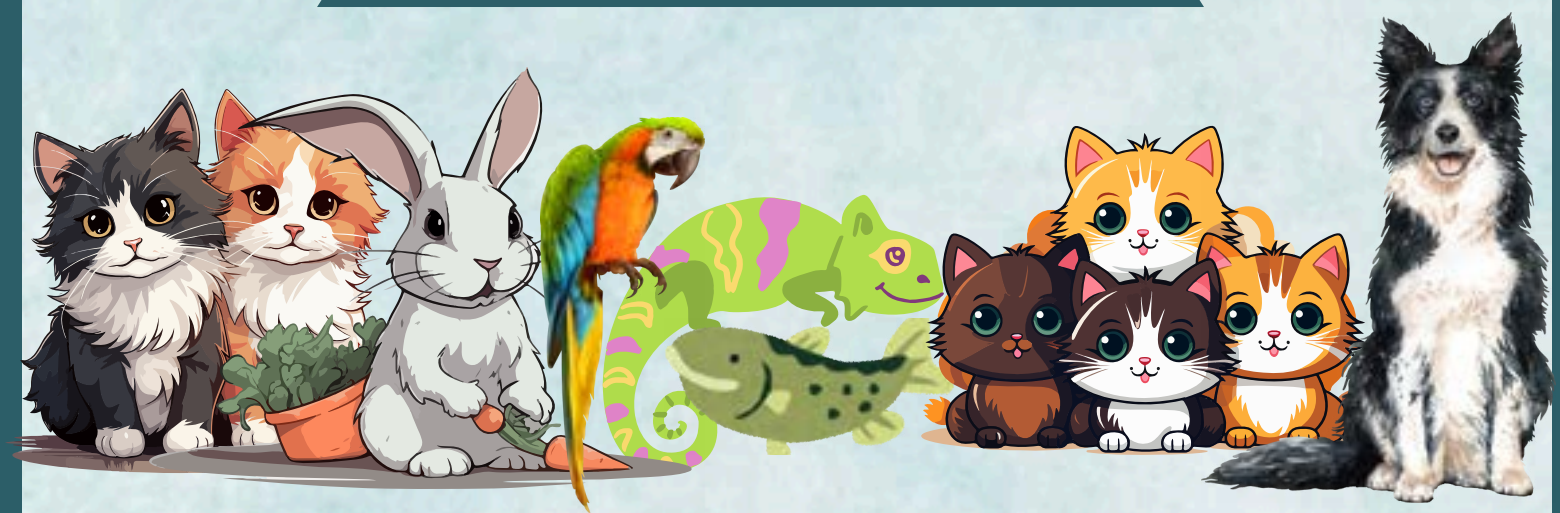

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NVF VETOPIA PUNE 28-30 NOV 2024 Lecture Schedule

Date:	DAY ONE Thursday 28 Nov 2024	
TIME		SPEAKER
11:00 AM -1.00 PM	Registration + Room Allocation + Stall Visits	
1:00 PM - 2:00 PM	Lunch	
2:00 PM - 2.30 PM	OPENING CEREMONY	
2:30 PM - 3.30 PM	How to perform a neurological examination in practice	Dr.Steven De Decker
3.30 PM - 4.30 PM	How to recognise the most likely underlying condition without expensive diagnostics	Dr.Steven De Decker
4.:30 PM - 5:00 PM	Stall Visits/ (Tea/ Coffee) Ground oor	
5:00 PM - 5:15 PM	Prime sponsor SAVA	
5:15 PM - 6:15 PM	Neonatal medical care -they are not born to die	DrKGUmesh
6:15 PM - 6:30 PM	Prime sponsor DROOLS	
6:30 PM- 7:30 PM	Understanding Arterial blood gas analysi	Dr K Jeyaraja
7:30 PM ONWARDS	Freshen up, Get Ready to Shine & Sparkle Enjoy the BEATS	
8:00 PM - 8:30 PM	Entertainment Programme	
8:30 PM TO 11:00 PM	Finger food, Cocktails & GALA Dinner!	

DAY 2 Friday 29 Nov 2024		
7:30 AM TO 9:00 AM	Special Lecture SAVA	
9:15 AM - 10:15 AM	How to approach acute hindlimb paralysis in practice	Dr.Steven De Decker
10:15 AM - 10:25 AM	Platinum Sponsor VIVALDIS	
10:25 AM - 11:10 AM	Feline spinal disease	Dr.Steven De Decker
11:10 AM - 11.30 AM	Tea/Coffee Break /Stall visits	
11:30 AM – 12:15 PM	Interactive session on other Neurological queries/challenges	Dr.Steven De Decker
12:15 PM - 12:25 PM	Platinum sponsor ALLANA	
12:25 PM - 1:15 PM	IMHA and IMTP- current recommendations for management	Dr.K G Umesh
1:15 PM- 2:15 PM	LUNCH	
2:15 PM - 3:00 PM	What is the practical difference between CT and MRI and how to start interpretation	Dr.Steven De Decker
3:00 PM – 3:10 PM	Diamond Sponsor ROYAL CANIN	
3:10 PM- 3:20 PM	Diamond sponsor OPUS PET	
3:20 PM - 4:05 PM	MRI and CT of spinal disorders part I (case-based discussions)	Dr.Steven De Decker
4:05 PM - 4:35 PM	Tea Break/ Stall visit	
4:35 PM- 5:20 PM	MRI and CT of spinal disorders part II (case-based discussions)	Dr.Steven De Decker
5:20 PM - 5:25 PM	Diamond sponsor PANAV BIOTECH	
5:25 PM - 5:30 PM	Diamond sponsor VETRINA	
5:30 PM - 5:35 PM	Diamond sponsor FREOSSI	
5:35 PM - 6:15 PM	How to Approach Vestibular Syndrome in practice	Dr.Steven De Decker

DAY 2 Friday 29 Nov 2024		
6:15 PM - 7:15 PM	Felicitation of Gold and Silver Sponsors	
	FRESHEN UP	
8 PM - 8:30 PM	Cultural Program	
8:30 PM - 11:00 PM	Cocktails and GALA Dinner	Dr.Steven De Decker

DAY 3 Saturday 30 Nov 2024		
9:00 AM - 9:45 AM	MRI and CT of brain disorders part I	Dr.Steven De Decker
9:45 AM - 10:15 AM	MRI and CT of brain disorders part II	Dr.Steven De Decker
10:15 AM - 10:25 AM	Diamond sponsor FARMINA	
10:25 AM - 10:40 AM	Diamond sponsor PET MANKIND/ PET STAR	
10:45 AM -11.30 AM	Compelling Canine Cardiovascular Case studies:An in depth Exploration	Dr.K Jeyaraja
11:30 AM-12:15 PM	In continuation	Dr.K Jeyaraja
12:15 PM – 12:30 PM	LUCKY DRAW!!!	
12:30 PM - 12:45 PM	Vote of Thanks	
12:45 PM - 2:00 PM	Check out and LUNCH!	

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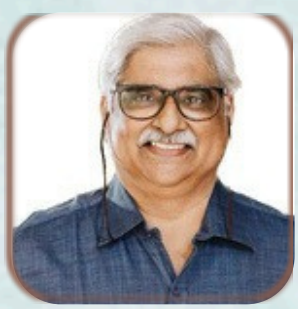

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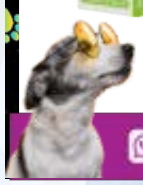

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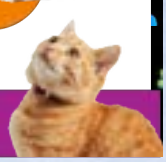

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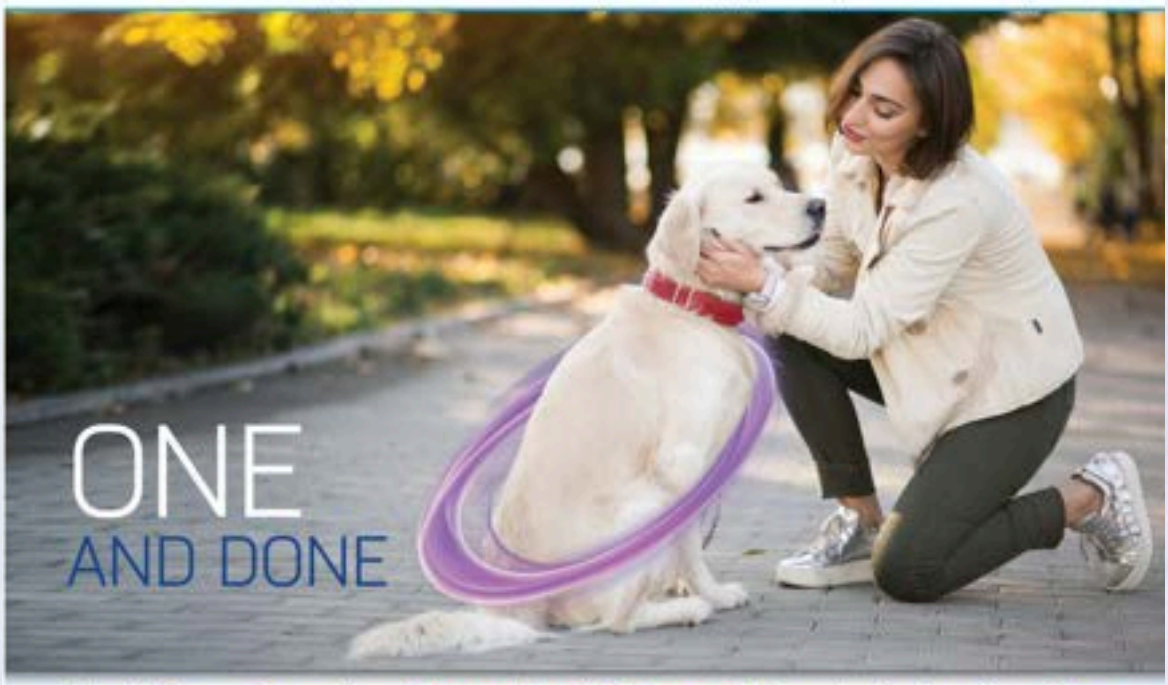

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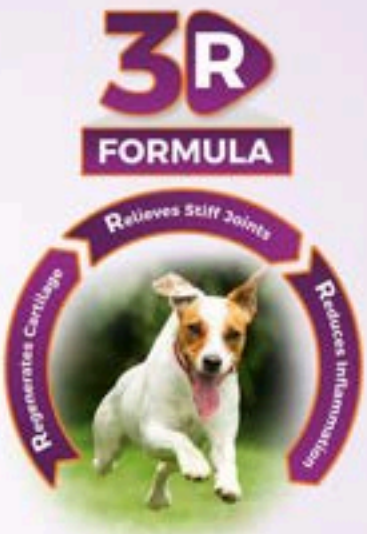

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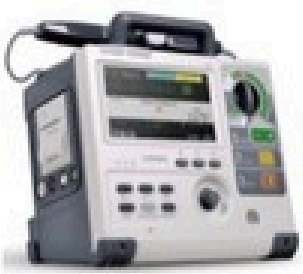

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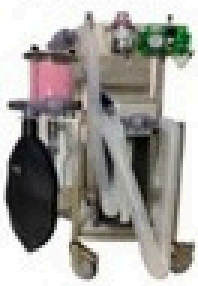

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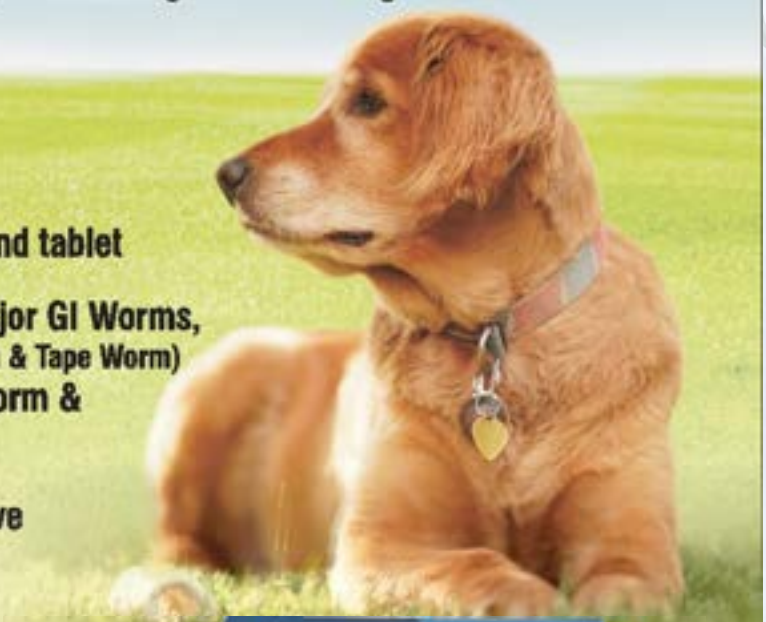

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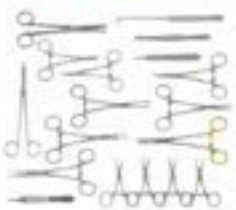

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HOW TO PERFORM A NEURO EXAM IN PRACTICE ?

Steven De Decker

Royal Veterinary College, United Kingdom

LEARNING OUTCOMES:

- Become familiar with the basic components of the neurological examination
- Learn how to perform a neurological examination in a structured manner
- Become confident identifying the neuro-anatomical localization.

Successful management of animals with suspected neurological disease can be a daunting and stressful prospect. It is however important to have a calm, structured, and logical approach when confronted with neurologically abnormal animals. A good understanding of the basic principles of the neurological examination is key to becoming more confident when evaluating neurological patients.

After performing a neurological examination, you should be able to answer the following questions: (1) Is the animal having a neurological disease, (2) Which part of the nervous system is affected, and (3) sometimes, you can determine the prognosis. Predicting the prognosis will only be possible in a minority of cases with specific clinical presentations, such as acute spinal injury and head trauma. It is important to realise that the severity of clinical signs does often NOT correlate with likelihood of recovery. This Information is crucial for obtaining a reliable list of differential diagnoses.

BEFORE PERFORMING A NEUROLOGICAL EXAMINATION

Although it is tempting to immediately perform a neurological examination, it is important to first obtain a detailed clinical history and perform a complete general physical examination. In several situations, the animal will be completely normal when presented to you. Examples of this are seizures and movement disorders. Information from the clinical history will then be the most important factor in selecting appropriate diagnostic and treatment options. Neurological abnormalities can also be caused by systemic diseases, which can only be recognized after a thorough general physical examination.

BASIC COMPONENTS OF THE NEUROLOGICAL EXAMINATION

The neurological examination can be divided in the hands-off and hands-on examination. The hands-off examination is of great importance and often reveals key findings. The hands-off examination is unfortunately often overlooked. The neurological examination is further divided into the following 7 components; (1) Mentation and behaviour, (2) Posture and gait, (3) Proprioception, (4) Cranial nerves, (5) Spinal reflexes, (6) Spinal palpation, and (7) Nociception. It is important to start with the least invasive parts of the neurological examination and keep the more invasive parts for the end. Evaluating spinal pain and nociception/pain sensation can be considered the most invasive parts of the neurological examination.

1. *Mentation and behaviour*: Mentation and behaviour are not the same. In Neurology patients, ***abnormal mentation*** is most often characterised as decreased responsiveness or decreased consciousness. A larger than normal stimulus should be applied before you receive a response. Progressively decreasing levels of mentation are obtundation, stupor, and coma. Mentation can be decreased in forebrain and brainstem disorders. It is often more profoundly decreased in brainstem disorders.

   Abnormal behaviour is characterised by an inappropriate interaction with the environment Examples of abnormal behaviour include circling, compulsive pacing, and head-pressing. Abnormal behaviour is suggestive for forebrain disease. A common misconception is to consider aggression as a common sign of forebrain dysfunction. It is highly unlikely for dogs with neurological disease to have aggression-related behaviour problems as their predominant clinical sign. In endemic regions, Rabies could be an exception to this rule

   .

2. *Posture and gait*: abnormalities in posture include low-head carriage, kyphosis, head tilt. Abnormalities in gait include paresis, ataxia, and lameness. It is important to realize that ataxia (= loss of coordination) and paresis (= weakness) are different concepts. Animals with ataxia can have cerebellar or vestibular disease, animals with paresis can have lumbosacral or generalised neuromuscular disease, while animals with both ataxia and paresis can have spinal or brainstem disease.

3. *Proprioception*: This is often evaluated by hopping or paw placement responses in dogs, while visual placing, tactile placing, and wheel barrowing are useful in cats. Proprioceptive deficits are a reliable indicator for the presence of neurological disease. Proprioceptive deficits can occur in forebrain, brainstem, and spinal disease.

4. *Cranial nerves*: It is important to realise that performing a specific cranial nerve test often evaluates multiple anatomical structure and often more than one specific cranial nerve. Isolated cranial nerve deficits can be associated with specific idiopathic conditions. Certain combinations of cranial nerve deficits can be suggestive for inner ear localisations, while multiple cranial nerve deficits can occur in brainstem or generalized lower motor neuron disorders.

5. *Spinal reflexes*: Evaluation of spinal reflexes, such as the withdrawal reflex and patella reflex, is indicated to recognize focal or generalized lower motor neuron disease. It is also performed to evaluate which spinal cord segment is affected in animals with spinal cord disease. Decreased spinal reflexes indicate that a lesion is present in the local reflex arc, which includes the peripheral nerves and related spinal cord segment.

6. *Spinal palpation:* it is important to start with gentle palpation when you suspect the presence of spinal pain.

7. *Nociception*: Because this part of the examination is unpleasant, evaluation of nociception or 'pain sensation' should only be performed in paraplegic and comatose animals. It is important to realize that the response of the withdrawal reflex and nociception have a different nature and should not be confused.

DETERMINING THE NEURO-ANATOMICAL LOCALISATION

The combination of clinical signs and findings of the neurological examination is used to determine the neuro-anatomical localisation. This will consist of one of the following; (1) forebrain, (2) cerebellum, (3) brainstem, (4) spinal cord, and (5) Neuromuscular.

1. Forebrain: Clinical signs include seizures, decreased mentation, abnormal behaviour, and central blindness. Additional neurological deficits include decreased menace response, decreased response after stimulation of the nasal mucosa, and proprioceptive deficits.

2. Cerebellum: Clinical signs include ataxia without paresis, hypermetria, central vestibular disease, and intention tremors. Additional neurological deficits include a decreased menace response.

3. Brainstem: Clinical signs include decreased mentation, generalised ataxia, hemiparesis, tetraparesis, and vestibular disease. Additional neurological deficits include proprioceptive deficits and cranial nerve deficits.

4. Spinal cord: Clinical signs include a combination of ataxia and paresis, spinal hyperesthesia, and bladder dysfunction. Additional neurological deficits include proprioceptive deficits and alterations in spinal reflexes.

5. Neuromuscular: The hallmark of neuromuscular disease is paresis without ataxia. Other clinical signs include changes in voice and regurgitation. Additional neurological deficits can include decreased spinal reflexes and cranial nerve deficits.

DETERMINING PROGNOSIS

Although prognosis for an individual animal is largely dependent on the specific diagnosis, the neurological examination can provide prognostic information in selected cases. Loss of nociception or pain sensation is the most important clinical prognostic factor in animals with spinal disease. Negative prognostic factors for animals with traumatic brain injury are comatose mental status with bilateral mydriatic pupils and negative pupillary light reflexes, decerebrate rigidity, and a prolonged comatose mental status (>48hours).

HOW TO RECOGNISE THE MOST LIKELY DIFFERENTIAL DIAGNOSIS IN PRACTICE?

THE CONCEPT OF CLINICAL REASONING

Steven De Decker
Royal Veterinary College, United Kingdom

LEARNING OUTCOMES:

- Become familiar with different strategies to identify the most likely underlying diagnosis.
- Learn about the principles of a problem-based clinical reasoning approach.
- Learn how easy-to-identify clinical characteristics can be used to identify the most likely differential diagnosis.

It is common to feel uncomfortable and unconfident when confronted with an animal with suspected neurological disease. Although several factors can be responsible for this 'neurophobia', it is often wrongly assumed that all neurology patients need to be referred to a specialty centre for advanced and expensive diagnostics, such as magnetic resonance imaging (MRI). Not all neurology patients can however be referred, not all neurologically abnormal animals need to be referred, and not all referred patients will require advanced diagnostics. Although patients with neurological disease can present with spectacular clinical signs and emotionally distressed owners, the clinical approach to these patients is not necessarily different from animals affected by other disorders. The combination of a thorough clinical history, general physical examination, and neurological examination will enable you to list the most likely differential diagnoses for the individual patient. This will serve as a starting point to discuss further diagnostics and management options with your client.

DIAGNOSTIC APPROACHES NOT SUITABLE FOR NEUROLOGICAL PATIENTS: PATTERN RECOGNITION AND "FISHING"

Experienced veterinary surgeons can rely on pattern recognition to achieve most of their clinical diagnoses. This is especially true for common diseases with unique and specific clinical signs. This diagnostic approach becomes however problematic for less experienced clinicians, uncommon diseases or disorders characterized by unspecific clinical signs. Neurological disorders are unsuitable for diagnosis by pattern recognition; not the disease itself, but the location of the disease within the nervous system will dictate the nature of clinical signs.

This has two clinical consequences:

(1) different diseases affecting the same location in the nervous system can cause similar clinical signs,

(2) A specific disease may affect different locations in the nervous system and can therefore present with variable clinical signs.

"***Fishing***" , diagnosis by exhaustion, or performing a variable amount of diagnostic tests in the hope to find potential abnormalities, should also be considered less ideal in neurology patients. Routine diagnostic tests, such as haematology, biochemistry, and even analysis of cerebrospinal fluid are rarely specific for a given neurological disease. Inappropriate selection of diagnostics can cause the owner to run out of money before a final diagnosis has been reached. "Fishing" for abnormal findings becomes also problematic when using the most sensitive neurodiagnostic procedure, MRI.

PROBLEM BASED CLINICAL REASONING

Problem based clinical reasoning involves a logical progression through the following steps: (1) Define the problem of your patient. This can include pain, a gait abnormality, seizures, or abnormal behaviour. (2) Define which body system is affected. Neurological disorders can sometimes be difficult to differentiate from disorders affecting other body systems, (3) Define the location of the problem.

For neurological disorders this can include the forebrain, brainstem, cerebellum, spinal cord or peripheral neuromuscular disease. (4) Define the lesion. Now a list of likely differential diagnoses should be obtained. The answers to questions (1), (2), and (3) are answered after obtaining a thorough clinical history (what is the actual complaint?) and performing a complete general physical and neurological examination.

Define the lesion – How to get more from your neurological examination

Traditionally, a list of differentials was obtained using the VITAMIN D or DAMNIT-V scheme. Several neurological diseases can however be divided in more than one of these categories and this system does not always allow you to narrow down your list of differentials to only the most likely disorders for your individual patient. More recent developments in medical education advocate a problem-based approach following the principles of clinical reasoning. More specifically, neurological disorders are associated with specific clinical characteristics and considering these specific clinical characteristics can be used to recognize the most likely differentials for an individual patient. After identifying the neuro-anatomical localisation, the most important clinical characteristics are (1) onset of clinical signs, (2) progression of clinical signs, (3) symmetry of clinical signs, (4) presence or absence of pain, and (5) patient's signalment. This diagnostic approach can also be referred to as the "5-finger-rule".

(0) Neuro-anatomical localisation

Obtaining a neuro-anatomical localisation is the starting point of obtaining a reliable list of differentials. Several neurological conditions will affect a specific or preferential part of the nervous system.

(1) Onset

The onset of clinical signs is typically divided into peracute, acute, and chronic. It is important to consider the difference between peracute (seconds to minutes) and acute (hours to days) onset of clinical signs. Although several neurological conditions are characterized by an acute onset of clinical signs, only a few are characterized by a peracute onset. Examples of disorders with a peracute onset are vascular (for example, ischemic myelopathy) and idiopathic disorders (for example, idiopathic vestibular disease). Classical chronic conditions, such as neoplasia, can however also deteriorate acutely. This is referred to as "acute on chronic onset".

(2) Progression

Progression of clinical signs can be divided into improving, static, deterioration, waxing and waning, and episodic. The presentation of 'spontaneously improving neurological signs' might be more common than expected and can be seen in vascular disorders (for example, a cerebellar infarct), idiopathic disorders (for example, idiopathic Horner's syndrome), and pure contusive injuries (for example, acute non-compressive nucleus pulposus extrusion).

(3) Symmetry

Clinical signs can be symmetrical or strongly lateralized (asymmetrical). Examples of strongly lateralized brain conditions are neoplasia and vascular disorders. Examples of strongly lateralized spinal cord conditions are ischemic myelopathy and acute non-compressive nucleus pulposus extrusion.

(4) Pain

Neurological disorders, especially spinal disorders, can be painful. Presence of pain excludes several other conditions, such as degenerative myelopathy and ischemic myelopathy. Animals with classical painful conditions, such as compressive intervertebral disk disease, are however not always overtly painful. These conditions should therefore not be excluded if no obvious pain can be elicited on spinal palpation.

(5) Signalment

Neurological conditions commonly occurring in one species are very rare or do not occur at all in other species. Different neurological conditions should therefore be considered in dogs and cats. Congenital and infectious disorders are more common in young animals, while neoplastic and degenerative conditions are more common in older animals. Neurological conditions can also be associated with gender and breed. Caution should however be exercised because not every neurologically abnormal Dachshund will have intervertebral disk disease.

Problem based clinical reasoning has been demonstrated to be valuable in the diagnostic approach of dogs and cats with spinal disease, epilepsy, vestibular syndrome, and canine cervical hyperesthesia. It allows inexperienced clinicians to obtain a reliable list of differentials in animals with neurological disease.

HOW TO APPROACH ACUTE HIND LIMB PARALYSIS IN DOGS?

Steven De Decker
Royal Veterinary College, United Kingdom

LEARNING OUTCOMES:

- Become confident in the initial assessment of dogs with hind limb paralysis.
- Learn how to use easy-to-identify clinical characteristics to identify the most likely differential diagnosis.
- Learn how to differentiate between surgical and non-surgical causes of acute hindlimb paralysis.

It is often assumed that dogs with acute hind limb paralysis carry a poor prognosis and need to be referred to specialty centres for advanced and expensive diagnostics. Despite the severity of their clinical presentation, animals with acute hind limb paralysis can often be assessed and successfully treated in first opinion practice.

INITIAL ASSESSMENT OF ANIMALS WITH ACUTE HIND LIMB PARALYSIS

If an animal is presented with multiple injuries, do not immediately focus on the neurological signs. You should, if present, focus first on more life-threatening abnormalities. After obtaining a clinical history and performing a general physical examination, a neurological examination should be performed. Findings of the neurological examination will indicate if the animal has indeed spinal disease, which part of the spinal cord is affected and can offer prognostic information. The most important aspects of the neurological examination in animals with suspected spinal disease are 1) observation of gait and posture, 2) evaluation of proprioception, 3) spinal reflexes, 4) presence of spinal pain and 5) evaluation of deep pain perception or nociception.

The pathophysiology of acute spinal cord injury is complex and can be divided into primary and secondary spinal cord injury. The primary injury represents immediate physical damage to the spinal cord and vasculature at the time of injury. This is followed by the secondary injury, which represents a cascade of biochemical and metabolic events initiated by the primary injury. The majority of this secondary spinal cord injury occurs in the first 24-48 hours after the primary injury.

Decreased spinal cord perfusion is considered an important factor in secondary spinal cord injury. It can therefore be considered to stimulate spinal cord blood flow by providing adequate IV fluid therapy. High doses of corticosteroids have historically been considered to decrease the damaging effects of secondary spinal cord injury. Results from more recent human and veterinary studies do however not demonstrate any benefit and suggest a higher risk of potentially life-threatening complications when administering high doses of corticosteroids in patients with acute spinal cord injury. **It is therefore no longer recommended to routinely administer corticosteroids in patients with acute spinal disease.**

TOP 4 DIFFERENTIALS FOR ACUTE HIND LIMB PARALYSIS IN DOGS

The 4 most common causes of acute hind limb paralysis in dogs are acute compressive intervertebral disc extrusion, ischemic myelopathy, acute non-compressive nucleus pulposus extrusion (ANNPE), and spinal fracture/luxation.

Acute compressive intervertebral disc extrusion

Acute compressive intervertebral disc extrusion, or Hansen type I intervertebral disc disease typically affects chondrodystrophic dog breeds between 3 and 7 years old. The Dachshund and French bulldog are especially vulnerable. Clinical signs have an acute onset and are often progressive. Spinal pain is typically present, especially in the early stages of disease. Ambulatory dogs are often managed medically with a combination of strict rest, anti-inflammatory drugs and analgesia. Surgery is typically recommended in non-ambulatory dogs and is associated with a good prognosis if deep pain perception is present. If deep pain perception is absent, 50-60% of dogs will still have a good outcome.

AIschemic myelopathy and acute non-compressive nucleus pulposus extrusion.

Ischemic myelopathy or fibrocartilaginous embolism and ANNPE (previously also referred to as traumatic intervertebral disc extrusion and high-velocity low-volume disc extrusion) have a similar, almost identical, clinical presentation.

In contrast to dogs with type I intervertebral disc disease, both disorders are associated with a peracute instead of an acute onset of clinical signs. Clinical signs typically occur in just a few seconds and are often associated with strenuous activity, such as running in a field or chasing/jumping for a tennis ball. ANNPE can also be associated with external trauma and should therefore be considered an important differential for vertebral fracture/luxation. Large non-chondrodystrophic dog breeds are most often affected. Although clinical signs can progress in the first 24 hours after onset, both disorders are typically non-progressive. It is not uncommon to see some spontaneous improvement within the first hours after onset of clinical signs. Although dogs often yelp when clinical signs occur, spinal pain is not an obvious feature during examination. Clinical signs can be dramatically lateralized and this should raise suspicion for both disorders. These are non-surgical conditions and physiotherapy/hydrotherapy forms the cornerstone of treatment. Prognosis is considered good if pain perception is present.

Vertebral fracture/luxation

Vertebral fracture/luxation has a peracute onset of clinical signs and is most often associated with external trauma. Animals are often obviously painful. Assessment of vertebral instability and severity of clinical signs will determine if dogs can be managed medically or surgically.

HOW TO RECOGNIZE THE MOST LIKELY DIAGNOSIS?

Acute spinal disorders are associated with specific clinical characteristics and a high index of suspicion can be reached after following the principles of clinical reasoning (‘5 finger rule’). This is especially important because not all dogs with acute hind limb paralysis will have a surgical condition and these non-surgical conditions are associated with the most characteristic clinical presentation. In other words, you should be able to recognise non-surgical causes of acute hind limb paralysis in first opinion practice. After identifying the neuro-anatomical localisation, the most important clinical characteristics are (1) onset of clinical signs, (2) progression of clinical signs, (3) symmetry of clinical signs, (4) presence or absence of spinal pain, and (5) patient’s signalment.

(1) Onset

It is important to consider the difference between peracute (seconds to minutes) and acute (hours to days) onset of clinical signs. Ischemic myelopathy, ANNPE and vertebral fracture/luxation are associated with a peracute onset of clinical signs. Acute compressive intervertebral disc extrusion is often associated with an acute onset of clinical signs.

(2) Progression

Progression of clinical signs can be divided into improving, static, deterioration, and episodic. Ischemic myelopathy and acute ANNPE are associated with spontaneously improving or static clinical signs. Acute compressive intervertebral disc extrusion can be associated with progressive clinical signs.

(3) Symmetry

Clinical signs can be symmetrical or strongly lateralized. Ischemic myelopathy and ANNPE can be associated with symmetrical or strongly lateralized clinical signs.

(4) Pain

Acute spinal disorders can be painful or non-painful. Ischemic myelopathy and ANNPE are typically not associated with obvious spinal pain. Vertebral fracture/luxation is often associated with severe spinal pain. Animals with classical painful conditions, such as compressive intervertebral disk extrusion, are however not always overtly painful. Although spinal pain or spinal hyperaesthesia is often the predominant clinical sign early in the disease process, it is often difficult to elicit spinal pain when clinical signs progress and animals become paralysed.

(5) Signalment

Ischemic myelopathy and ANNPE occur most often in middle-aged to older non chondrodystrophic dog breeds. Acute intervertebral disc extrusion occurs most often in young to middle-aged chondrodystrophic dog breeds.

Looking after paralysed patients and realistic expectations

Animals can make fantastic recoveries despite severe neurological signs. It is however important to have realistic expectations. Animals with acute hind limb paralysis will not recover the ability to walk in one or two days. This will be longer and animals need to be given the opportunity to demonstrate gradual and slow neurological improvement. In most acute spinal conditions, it can take up to two weeks until any obvious sign of improvement is seen. It is therefore important to be patient and provide appropriate nursing care until neurological function is restored. The cornerstone of nursing care for paralysed patients is bladder management. It should be assumed that animals unable to walk will also be unable to urinate voluntarily.

SPINAL DISEASE IN CATS

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LEARNING OUTCOMES:

- Become familiar with some feline specific causes of spinal disease.
- Become aware of the most common causes of spinal disease in cats.
- Learn how to recognise the most common cause of spinal disease in your feline patient.

Cats are affected with specific spinal disorders and common 'canine' spinal disorders are uncommon in cats. Cats should not be considered small dogs and it is important to consider a different diagnostic approach in cats with suspected spinal disease. Historically, the most common spinal disorders in cats were considered to be (1) inflammatory disease, particularly feline infectious peritonitis virus, (2) neoplastic disease, particularly spinal lymphoma, and (3) external trauma. Although by definition not a spinal disorder, arterial thromboembolism is the most common cause of acute paralysis in cats.

FELINE SPECIFC CAUSES OF PARALYSIS

Aortic thromboembolism

This devastating disorder should be considered in every cat with acute onset paralysis. Cats typically present with a neuromyopathy caused by embolization of the distal aorta. The clinical presentation is almost pathognomonic and is based on recognition of the five 'Ps': Pain, Paralysis, Pulselessness, Poikilothermy, and Pallor. This condition is often associated with advanced heart disease and carries a poor prognosis.

Feline infectious peritonitis virus

Feline infectious peritonitis (FIP) virus is caused by the virulent biotype of feline coronavirus. Neurologic signs are usually associated with the dry form, are progressive in nature, and usually not limited to a spinal cord localisation.

Multifocal central nervous system involvement is common and ocular abnormalities, such as chorioretinitis, can also be seen in combination with neurological signs. Recent developments have provided hopeful results for treatment of FIP

Spinal lymphoma

Neoplasia is historically considered the second most common feline spinal disorder with lymphoma being the most common tumour. Although animals with spinal tumours are generally older, cats with spinal lymphoma are significantly younger than cats with other spinal tumours. Cats with spinal lymphoma have a bimodal age distribution with 50% reported to be younger than 4 years of age and 25% older than 11 years. Cats with spinal lymphoma can have extraneural involvement with kidneys and bone marrow most often affected. Affected cats can therefore suffer from non-specific clinical signs such as anorexia, lethargy, weight loss, and respiratory tract disease. Although making a definitive diagnosis requires taking surgical biopsies, this is often not feasible for tumours affecting the spinal cord. Spinal lymphoma can be diagnosed by positive cytology on blood smears, bone marrow, cerebrospinal fluid, or obtaining fine needle aspirate biopsies of identified extraneural sites.

FELINE SPECIFC CAUSES OF PARALYSIS

A study evaluating 221 cats with spinal disease revealed that the 10 most common feline spinal disorders diagnosed at the RVC are:

1. Spinal neoplasia (non-lymphoid) – 19.9% of cases
2. Intervertebral disc disease – 19.0%
3. Fracture and luxation – 15.4%
4. Ischaemic myelopathy – 10.0%
5. Feline infectious peritonitis virus myelitis – 8.1%
6. Lymphoma – 7.2%
7. Vertebral canal stenosis – 5.0%
8. Acute non-compressive nucleus pulposus extrusion – 5.0%
9. Traumatic spinal cord contusion – 5.0%
10. Spinal arachnoid diverticulum – 3.2%

It is important to note that more than 95% of cats with spinal disease are represented by the 10 most common conditions. In agreement with previous suggestions, spinal neoplasia was a very common spinal disorder in cats. It is however clear that some conditions that are traditionally considered to be uncommon in cats, such as intervertebral disc disease, where more prevalent in our study. A potential reason for this different distribution could be that previous studies have used post-mortem examinations to obtain a definitive diagnosis. Although this has the clear advantage of being able to make a final diagnosis, it is possible this has caused a shift towards conditions with a poor prognosis.

CLINICAL REASONING IN FELINE SPINAL CORD DISEASE

The ultimate aim is to recognise the 2 or 3 most likely differential diagnoses before further diagnostics, treatment and prognosis are discussed with the owner. It should be avoided to list all possible differential diagnoses for a given clinical problem.

Clinical reasoning is the process in which different clues of information and specific parts of the clinical presentation are integrated and used to influence your clinical decision making. Important clinical characteristics to consider in cats with spinal disease are: 1) neuro-anatomical localisation, 2) results of a general physical examination/presence of concurrent clinical signs, 3) onset of clinical signs, 4) progression of clinical signs, 6) presence of spinal pain, 7) symmetrical or lateralizing clinical signs 7) signalment

(1) Neuro-anatomical localisation

Obtaining a neuro-anatomical localisation is the starting point for obtaining a reliable list of differentials. Specific spinal disorders can affect a preferential spinal cord segment. You therefore start localising the lesion to one of the following spinal cord segments:

- C1-C5 spinal cord segments
- C6-T2 spinal cord segments
- T3-L3 spinal cord segments
- L4-S3 spinal cord segments

(2) Results of a general physical examination and clinical history

Some common feline spinal conditions can be caused by systemic disorders. It is therefore important to perform a thorough general physical examination and evaluate if other, maybe less specific, clinical signs are present. Examples include lethargy, anorexia and weight loss.

(3) Onset

The onset of clinical signs is typically divided into peracute, acute, and chronic. It is important to consider the difference between peracute (seconds to minutes) and acute (hours to days) onset of clinical signs. Although several neurological conditions are characterized by an acute onset of clinical signs, only a few are characterized by a peracute onset. Examples of disorders with a peracute onset are vascular and traumatic conditions.

(4) Progression

Progression of clinical signs can be divided into improving, static, deterioration, and episodic. The presentation of ‘spontaneously improving neurological signs’ can be seen in vascular disorders and pure contusive injuries (for example, acute non compressive nucleus pulposus extrusion).

(5) Symmetry

Clinical signs can be symmetrical or strongly lateralised (asymmetrical). An example of disorder that can be strongly lateralised is ischemic myelopathy.

(6) Pain

Spinal disorders can be painful. Presence of pain excludes several conditions, such as ischemic myelopathy and spinal cord contusion.

(6) Signalment

Congenital and infectious disorders are more common in young animals, while neoplastic and degenerative conditions are more common in older animals. Spinal lymphoma occurs most often in young animals and should be considered an important differential in young cats with progressive spinal disease. Spinal disorders can also be associated with breed. Purebred cats, especially British shorthairs and Persians, are predisposed for intervertebral disc disease.

HOW TO APPROACH VESTIBULAR SYNDROME IN PRACTICE

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LEARNING OUTCOMES:

- Become familiar with the clinical signs associated with vestibular syndrome.
- Learn how to differentiate between central and peripheral vestibular syndrome.
- Become familiar with the most common causes of vestibular syndrome in dogs and cats.

The vestibular system, or 'system of balance', is responsible for maintaining a normal orientation of the body, head and eyes in relation to gravitational forces and maintaining a normal position of the body and eyes in relation to motion or position of the head. The vestibular system has a complicated anatomy and clinical signs can be caused by disorders outside or inside the central nervous system. These locations are also referred to as peripheral or central vestibular syndrome, respectively. Veterinary surgeons confronted with an animal with vestibular dysfunction need to evaluate if patients with vestibular disease are more likely affected by peripheral or central vestibular syndrome.

ANATOMY OF THE VESTIBULAR SYSTEM

The peripheral components of the vestibular system are located in the inner ear and consist of the receptors, ganglion, and the vestibular division of the vestibulocochlear nerve (Cranial nerve VIII). The central vestibular components are the vestibular nuclei in the brainstem, vestibular divisions in the brainstem, and the flocculonodular lobe of the cerebellum, fastigial nucleus of the cerebellum and the caudal cerebellar peduncle. More recently, it has been recognized that specific structures in the thalamus, which is located in the forebrain, also play a role in vestibular function.

Although not directly involved with vestibular function, parts of the facial nerve (cranial nerve VII) and sympathetic innervation to the eye run in close anatomical proximity to components of the peripheral vestibular system. More specifically, the facial nerve and sympathetic innervation to the eye course through the middle ear. It is therefore possible to see a combination vestibular signs, facial nerve paresis and Horner's syndrome in animals with disorders affecting the middle and inner ear.

CLINICAL SIGNS IN VESTIBULAR SYNDROME

Dysfunction of the vestibular system is associated with a typical complex of clinical signs, involving postural, gait, and ocular abnormalities. Head tilt is one of the easiest clinical signs to recognize and the ventrally deviated ear is directed towards the affected side. Vestibular ataxia is characterized by a wide based stance and a tendency to fall, drift, or even roll towards the side of the lesion. Affected animals can also demonstrate circling towards the affected side with the circles being very tight around the axis. Ocular abnormalities can be more difficult to recognize and consist of pathological nystagmus and positional strabismus. Nystagmus, or the involuntary movement of eyes, is typically characterized by a jerk nystagmus, with the fast phase directed away from the lesion. The orientation of the nystagmus can be horizontal, rotary, or vertical. Nystagmus can be physiologic, which is evaluated during the vestibulo-ocular reflex, or pathological. Pathological nystagmus can be classified as spontaneous/ resting or positional nystagmus. Animals with vestibular disease can also demonstrate ipsilateral positional strabismus; extending the head upwards induces ventrolateral deviation of the eyeball with increased exposure of the dorsal sclera.

DIFFERENTIATION BETWEEN PERIPHERAL AND CENTRAL VESTIBULAR SYNDROME

Because central vestibular syndrome is most commonly associated with disorders affecting the cerebellum or brainstem, affected animals can also demonstrate other brainstem or cerebellum signs. Presence of proprioceptive deficits and hemiparesis at the side of the lesion, tetraparesis, decreased mentation, and multiple cranial nerve deficits are suggestive for central vestibular syndrome. Because the facial nerve (Cranial nerve VII) and the Sympathetic nerve are anatomically closely related to the inner ear, facial nerve paresis and Horner's syndrome can be seen in animals with peripheral vestibular syndrome. Although debatable, pure vertical nystagmus is also considered suggestive for a central vestibular syndrome. Nystagmus that changes direction when position of the head is changed (for example from horizontal to rotatory after elevating the head) and disconjugate nystagmus are also indications for central vestibular syndrome. Disconjugate nystagmus is characterized by both eyes displaying jerk nystagmus in a different direction. The rate of resting nystagmus has also been demonstrated to be significantly higher in dogs with peripheral vestibular syndrome.

Caution should however be exercised. Although the presence of the above discussed abnormalities is suggestive or diagnostic for a central vestibular syndrome, their absence does not exclude a central cause for vestibular dysfunction. **A central vestibular localization can be ruled in, but not ruled out.**

PARADOXICAL VESTIBULAR SYNDROME

Although proprioceptive deficits occur usually at the same side as the head tilt, animals with central vestibular syndrome will occasionally demonstrate proprioceptive deficits contralateral to the side of the head tilt. This specific presentation is referred to as a paradoxical vestibular syndrome and is associated with a lesion affecting the caudal cerebellar peduncle.

BILATERAL VESTIBULAR SYNDROME

Bilateral vestibular syndrome is occasionally seen and is characterized by the absence of a head tilt and absence of any type of nystagmus. These animals will also not demonstrate physiologic nystagmus and will have a negative vestibulo-ocular reflex. Affected animals can crouch low over the floor, fall to both sides, and demonstrate wide bilateral excursions of the head. The most common causes of bilateral vestibular syndrome are bilateral middle/inner ear conditions.

COMMON CAUSES OF VESTIBULAR SYNDROME

In the author's institution, the most common causes of vestibular syndrome in dogs are:

- Idiopathic vestibular syndrome – 34.2%
- Otitis media/interna – 23.7%
- Meningoencephalitis of unknown origin (MUO) – 15.4%
- Brain neoplasia – 11.4%
- Ischemic infarct – 11%
- Intracranial empyema (intracranial expansion of otitis interna) – 1.7%
- Metronidazole toxicity – 1.3%
- Middle ear neoplasia – 1.3%

Other potential causes for vestibular syndrome in dogs include hypothyroidism, congenital vestibular syndrome, trauma, ototoxicity, hydrocephalus, and infectious central nervous system disease.

In the author's institution, the most common causes of vestibular syndrome in cats are:

- Otitis media/interna – 27.6%
- Idiopathic vestibular syndrome – 22.4%
- Intracranial neoplasia – 13.8%
- Middle ear polyp – 9.8%
- Feline Infectious peritonitis (FIP) virus – 7.5%
- Thiamine deficiency – 7.5%
- Intracranial empyema (intracranial expansion of otitis interna) – 6.3%
- Ischemic infarct – 2.3%

Other potential causes for vestibular syndrome in cats include congenital vestibular syndrome, trauma, ototoxicity, and other infectious central nervous system disease.

It is important to realize that these conditions and numbers come from a referral institution in the United Kingdom. It is likely that the distribution of specific disorders will vary between primary care and referral practice, different countries, and different geographic regions. Although it is not important to know the exact prevalence of a condition in your population, the above percentages were added to illustrate a useful statistic: the 8 most common conditions represent more than 95% of dogs and cats with vestibular syndrome. In theory, you would therefore be able to help 95% of your patients if you would be able to diagnose and treat the 8 most common causes of vestibular syndrome.

CLINICAL REASONING IN ANIMALS WITH VESTIBULAR SYNDROME

The following steps are important when applying clinical reasoning to recognise the most likely differential diagnoses:

1. **Do a neuro-exam**: identify that the animal is suffering from vestibular syndrome and identify if the problem is most likely localized to the central or peripheral vestibular components.
2. **Recognise easy to identify clinical characteristics and characterize the clinical presentation:** for vestibular syndrome, the most important clinical characteristics are signalment, onset and progression of clinical signs, presence of nystagmus, presence of positional strabismus, presence of facial nerve paresis, presence of Horner's syndrome, presence of proprioceptive deficits, presence of cranial nerve deficits, and most likely neuro-anatomical localisation (central or peripheral).
3. **Be aware of the most common causes of vestibular syndrome in dogs and cats**. See above.
4. I**dentify which of those disorders can be associated with your key clinical characteristics**.
5. After you have identified the two or three most likely underlying conditions, discuss with the owners which **diagnostics, treatment options and outcome** can be considered for these specific conditions. Now you can decide if the animal needs to be referred or can be successfully treated in your practice.
6. **Reflection**. Evaluate if the patient is progressing as expected. If not, your differential diagnoses and clinical-decision-making should be re-evaluated. This step is especially important considering that a proportion of cases with presumptive peripheral vestibular syndrome will demonstrate a central lesion on advanced imaging.

WHY DO THE EPILEPTIC SEIZURES DON'T STOP? COMMON PROBLEMS IN EPILEPSY MANAGEMENT

Steven De Decker
Royal Veterinary College, United Kingdom

The unpredictable and violent nature of epileptic seizures can cause severe emotional distress to owners of affected animals. Successful management requires an accurate assessment of the patient and commitment of the owner. A good relationship and mutual respect between the veterinarian and client are crucial for the optimal management of epilepsy. It is therefore important that you feel confident about clinical decision making.

WHAT IF YOUR PATIENT DOESN'T RESPOND TO MEDICATION?

Although managing seizure patients can occasionally seem complex and difficult, it is important to go back to the basics when things don't go according to plan. This can be done by following the 'tripe D' mnemonic; Disease, Dose and Drug.

1. **DISEASE:**

   A common reason for unsuccessful therapy with anti-epileptic drugs (AEDs) is that the animal actually does not suffer from epileptic seizures. Several other 'paroxysmal' conditions can mimic seizures, which include syncope, REM-sleep disorders, narcolepsy/cataplexy and movement disorders. Movement disorders, including paroxysmal dyskinesias, are especially difficult to differentiate from seizures. It is obvious that animals suffering from the above conditions will not respond positively to AEDs. This highlights the importance of obtaining a good description of the events. The following information should be collected when obtaining a clinical history of a patient with suspected epileptic seizures: nature and duration of the episode, level of consciousness during the episodes, time during the day when the episode occurs, presence of autonomic signs, and type of behaviour when the actual 'seizure' has ceased. Seizures typically last no longer than 1-2 minutes, occur during rest or sleep, the animal cannot be distracted during the episode, it can demonstrate decreased or loss of consciousness and autonomic signs (e.g. urination, defecation, hypersalivation), and an epileptic seizure is typically followed by a postictal phase in which the animal can demonstrate a variety of behaviours such as ataxia, paresis, barking, howling, attention-seeking, increased appetite, blindness and aggression. These characteristics can be used to differentiate epileptic seizures from other paroxysmal disorders.

2. DOSE:

Another common cause of unsuccessful treatment is an insufficient dose of AEDs. It is well-known that metabolism of common AEDs can differ considerably between individual patients. Different patients will therefore require a different, individualised, dose. Assessment of the correct dose of common AEDs, such as phenobarbitone, can therefore only be evaluated by obtaining therapeutic serum concentrations. Two of the most common mistakes in the management of epilepsy are (1) failure to obtain therapeutic serum concentrations and (2) adding an additional AED before the first AED has been given maximum opportunity to be effective. In other words; a second AED is often added too soon without maximising the potential of the first AED. Although therapeutic serum concentration ranges vary between laboratories, they are often presented as a wide range. It is however important to adjust the dose until a serum concentration in the upper 75% of the therapeutic dose range is reached before considering the AED ineffective. For example:

- The therapeutic range of phenobarbitone is often presented as 20 to 40 ug/mL
- We will consider phenobarbitone ineffective ONLY if a therapeutic serum concentration between 30 and 35 ug/mL has not resulted in satisfactory seizure control.
- If the serum concentration is below 30 ug/mL, it is advised to increase the dose of phenobarbitone with the following formula: current dose X desired serum concentration/current serum concentration
- If a serum concentration between 30 and 35 ug/mL has not resulted in satisfactory seizure control, it should be considered to add another AED

2. DRUG:

It should be considered to add a second AED when no satisfactory response is reached despite adequate therapeutic serum concentrations of the first AED. It is important to know the indications and limitations of the available AEDs. It can be considered both frustrating and comforting that only a few AEDs can be used as maintenance drug. The AEDs that can be used as maintenance drug include phenobarbitone, potassium bromide, Imepitoin (Pexion©) and zonisamide.

Although Levetiracetam is a popular AED, which is useful in emergency situations, it is not effective as a maintenance AED in dogs. Studies have demonstrated a decreased effectiveness when levetiracetam is administered for a prolonged period of time, which has been referred to as the 'honeymoon' phenomenon. It should therefore not be considered as an add-on maintenance drug in dogs. The honeymoon phenomenon has not (yet) been reported in cats and levetiracetam could therefore be considered an alternative maintenance drug in this species.

When a patient does not respond satisfactory to a well-established AED, it is less likely to respond to a second AED. When patients do not respond to a second AED, it becomes unlikely they will respond to any AED. Drug-resistant or refractory epilepsy is considered when an animal does not satisfactorily respond to two well-established AEDs with evidence of adequate therapeutic serum concentrations. In practice this can be translated as a dog that continues to demonstrate uncontrolled epileptic seizures despite a receiving correct doses of both phenobarbitone and potassium bromide.

REFRACTORY EPILEPSY

Refractory epilepsy is characterised as a condition in which an animal with epilepsy fails to attain satisfactory seizure control or suffers intolerable side effects despite appropriate therapy with conventional AEDs. It seems unlikely that a patient with refractory epilepsy will respond to any AED. There is therefore a large interest in development of non-medical management of refractory epilepsy. Non-medical management in humans includes epilepsy surgery, electrical brain stimulation, vagal nerve stimulation, and dietary modification.

Epilepsy surgery and electrical brain stimulation are in its infancy in veterinary medicine and should currently not be considered realistic options in dogs and cats. Although vagal nerve stimulation has been evaluated to a greater extent, dietary modification has so far shown most promise in dogs with refractory epilepsy. Several human studies have demonstrated positive effects of a ketogenic diet in children with epilepsy. Possibly due to species differences in metabolism, a 'classic' ketogenic diet, consisting of high fat, low protein and low carbohydrate has not demonstrated improved seizure control in dogs. More recent studies have demonstrated promising results of a medium-chain triglyceride (TAG) diet in dogs with refractory epilepsy. It is however important to note that response to the medium-chain TAG diet is variable between individual dogs. While some dogs had a drastic improvement in epileptic seizure control, no positive effects were seen in other dogs. This information is of great importance when discussing expectations with owners.

What's the evidence for corticosteroid use in neurological patients?

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Corticosteroids are potent pharmacological agents. Depending on the dose, they have an anti-inflammatory effect, immunosuppressive effect, anti-edema effect, or cytotoxic effect versus neoplastic lymphocytes. Corticosteroids have historically been associated with neurology like a horse and carriage. They have therefore widely, almost arbitrarily, been used for a variety of neurological disorders. It was a popular belief that "everything neurological" should be treated with corticosteroids, The questionable efficacy of corticosteroids for most neurological presentations in combination with their unfavourable side effect profile has however resulted in a paradigm shift and a dramatic decrease of corticosteroid use in veterinary neurology.

Side effects of corticosteroids

Administration of corticosteroids is associated with predictable side effects which are similar to the clinical signs seen in animals with hypercortisolism (Cushing's disease). These include polyuria and polydipsia, polyphagia, decreased immune response with an increased risk of infections, muscle atrophy (especially the muscles of mastication), generalised muscle weakness, a pot-bellied appearance, excessive panting, lethargy, exercise intolerance, skin changes, delayed wound healing, and possible gut ulceration. Another concern of early corticosteroid administration in animals with neurological disease is the possible interference with diagnostic procedures and potential incompatibility with other drugs (like NSAIDs). It should be questioned if these side effects outweigh the potential benefits of corticosteroids.

Corticosteroids in acute spinal injury

The pathophysiology of acute spinal cord injury is complex, multifactorial and can be divided into a primary and secondary spinal cord injury. The primary injury represents immediate physical damage to the spinal cord and vasculature at the time of injury. This is followed by the secondary injury, which represents a cascade of biochemical and metabolic events initiated by the primary injury. The secondary spinal cord injury occurs predominantly within the first 24 to 48 hours after the moment of injury and results in progressive enlargement of the area of injury and necrosis. All animals with acute spinal injury can therefore demonstrate progression of clinical signs in the first 24-48 hours after the initial onset.

Decreased spinal cord perfusion, inflammation and formation of free-radical species have been considered to aggravate spinal cord injury. Experimental studies in rats suggested that methylprednisolone sodium succinate in a very high dose of 30mg/kg/IV at the time of, or immediately after, the injury would decrease the production of free-radical species. It has therefore historically been suggested that high doses of corticosteroids have the potential to limit the damaging effects of secondary spinal cord injury. Although this approach has been for long popular in human medicine, there was little evidence of its efficacy. Results of a randomized, controlled trial in 1990 (NASCIS II – the second National Acute Spinal Cord Injury study) suggested that if methylprednisolone given as a bolus of 30mg/kg/IV within 8 hours of the injury followed by a constant rate infusion at 5.4 mg/kg/IV for 23 hours resulted in significant improvement compared to those who received a placebo. Although an adapted protocol has been recommended and used for more than a decade in human and veterinary medicine, concerns about the NASCIS II trial became apparent. More specifically, questions were asked about the study design, statistical methods, and interpretation of the results. Moreover, the results of the NASCIS II trial could not be replicated in other studies and increasing concerns were raised about the safety of methylprednisolone. Studies in dogs with naturally occurring acute spinal cord injury have also not been able to demonstrate any beneficial effect of using corticosteroids in any shape or form. In contrast, several studies have suggested an increased incidence of severe side effects in patients (human and dogs) treated with corticosteroids. Corticosteroids are therefore currently not recommended as a standard of care in animals with acute spinal injury.

Corticosteroids in traumatic brain injury

Acute brain injury has a similarly complex and multifactorial pathophysiology like acute spinal injury (with primary brain injury followed by a secondary brain injury). The pathophysiology of acute brain injury includes inflammation, production of free radical species, and formation of cytotoxic oedema. Similar to the situation for acute spinal injury, it has historically been assumed that high doses of corticosteroids could limit the damaging effects of the secondary brain injury. Corticosteroids have further shown to decrease the effects of brain oedema in patients with brain tumors. Although corticosteroids are indeed effective in decreasing vasogenic oedema associated with brain tumors, they have no beneficial effect in decreasing cytotoxic oedema that is typically seen after traumatic brain injury. Corticosteroids have long been used as a first-line treatment in humans with traumatic brain injury. This practice was also supported in a meta-analysis of the available literature published in 1997.

The results of this meta-analysis were however questioned by several researchers and a large international prospective, randomized, placebo-controlled study (the CRASH trial – Corticosteroid randomisation after significant head injury) was organised in 2001. The CRASH trial revealed however undeniably that patients receiving corticosteroids were less likely to survive. In fact, the evidence was so overwhelming that patient recruitment for the CRASH trial was stopped in 2004 after initial analysis revealed a higher mortality rate in patients receiving corticosteroids. Corticosteroids are therefore not recommended, and should be considered contra-indicated, for the treatment of traumatic brain injury in humans. The increased risk of death in patients receiving corticosteroids for traumatic head injury are not completely clear and are likely multifactorial. Probably because of the results of this study in combination with current guidelines in human medicine, there are no studies that have evaluated the use of corticosteroids in dogs or cats with traumatic brain injury. Corticosteroid should however not be considered for the treatment of dogs or cats with acute head injury.

Corticosteroids in immune-mediated neurological disorders

The strongest indication for using corticosteroids in veterinary neurology is the treatment of immune-mediated neurological disorders, such as steroid responsive meningitis-arteritis (SRMA), meningoencephalitis of unknown origin/aetiology (MUO/MUA), corticosteroid-responsive tremor syndrome, and masticatory myositis. Despite their well-known side effects, glucocorticoids are still considered the first-line treatment in the management of immune mediated disorders of the nervous system. A possible reason for this is the relative rapid onset of action of corticosteroids, which is an important advantage for the acute management of central nervous system disorders. Although the clinical signs of these conditions can be well-controlled with corticosteroids, there are concerns that quality of life is affected by long-term corticosteroid use. This was illustrated in a study that evaluated the quality of life in dogs with SRMA. This study suggested that the primary factor affecting quality of life in dogs with SRMA is corticosteroid-related side effects and that a higher dose or longer duration of treatment are not necessarily associated by better control of the disease. There are therefore ongoing efforts to OR replace the use of corticosteroids by other medications OR limit the use of corticosteroids by decreasing the length of treatment. This is illustrated below with two examples:

(1) **Replacement of corticosteroids by other drugs in dogs with meningoencephalitis of unknown origin (MUO):** MUO is most often treated by life-long therapy with immunomodulating drugs, such as corticosteroids. Second-line treatments, such as cytosine arabinoside (cytarabine), cyclosporine, azathioprine,

and mycophenolate are increasingly used in dogs with MUO to limit the side effects of corticosteroids. Although it is currently unclear, and somewhat controversial, if adding second-line treatment results in improved disease control or survival, the primary aim of adding these agents is however the possibility for more aggressive tapering of corticosteroids. This will result in less pronounced side effects and an improved quality of life.

(2) **Shorter duration of corticosteroid administration in dogs with steroid responsive meningitis arteritis (SRMA):** In contrast to MUO, (1)SRMA is a self-limiting disease and is classically treated with a 6-months tapering course of corticosteroid. Although most dogs respond quickly and favourably to administration of corticosteroids, relapses of clinical signs can occur. As illustrated above, the primary factor that affects quality of life in patients with SRMA is corticosteroid-related side effects. There is further no evidence that more aggressive treatment results in a better control of the clinical signs. Results of a recent study have suggested that there was no significant difference in response to treatment (including prevalence of relapses) if dogs with SRMA were treated with the classical 6-months protocol or a shorter 6-weeks protocol.

Other indications for corticosteroid use in veterinary neurology

Corticosteroids can have a beneficial effect in animals with CNS neoplasia by reducing vasogenic oedema. Administration of corticosteroids can result in a rapid and dramatic improvement of clinical signs in animals with brain tumors. Dexamethasone is preferred over prednisolone for this purpose. Corticosteroids are also commonly used in the treatment protocol of animals with central nervous system lymphoma.

Although the exact working mechanism is unclear, corticosteroids have been shown to decrease production of cerebrospinal fluid (CSF) up to 50%. There is also some evidence that glucocorticoids can increase the rate of CSF absorption. Corticosteroids are therefore recommended for disorders characterised by CSF-flow disturbances, such as hydrocephalus and spinal arachnoid diverticula. A spinal arachnoid diverticulum is characterised by progressive focal expansion of the subarachnoid space caused by accumulation of CSF. Prednisolone 0.5mg/kg SID can be used for this purpose.

Chronic spinal cord compression is associated with vasogenic oedema. Corticosteroids, such as prednisolone, have therefore historically been used for the treatment of conditions associated with chronic spinal cord compression. Although this can result in an almost immediate improvement of clinical signs, longer term use can significantly affect quality of life. If corticosteroids are considered in animals with chronic spinal cord compression, such as Type II intervertebral disc protrusion or cervical spondylomyelopathy, only a short course should be considered.

Although the use of oral treatment with corticosteroids has dramatically decreased in veterinary neurology, use of local corticosteroids has gained popularity in recent years. The most common application of local corticosteroids is probably epidural infiltration of corticosteroids (with or without a local anaesthetic) in dogs with degenerative lumbosacral stenosis.

References – Available upon request

Multiple choice questions corticosteroids in veterinary neurology

1. Which statement is correct about the use of corticosteroids in acute spinal injury?

(A) High-doses of corticosteroids act as a free-radical scavenger and limit the effects of secondary spinal cord injury in dogs and cats.

(B) The currently recommended corticosteroid formulation and dosage for acute spinal cord injury is methylprednisolone sodium succinate 30mg/kg IV.

(C) Corticosteroids are not recommended in any form or shape in animals with acute spinal injury.

(D) Corticosteroids are recommended in animals with acute intervertebral disk extrusion, but not fracture luxation.

The correct answer is C.

2. Which statement is correct about the use of corticosteroids for traumatic brain injury?

(A) The currently recommended corticosteroid formulation and dosage for traumatic brain injury is methylprednisolone sodium succinate 30mg/kg/IV.

(B) The beneficial effects of corticosteroids in animals with traumatic brain injury is associated with its potential to decrease perilesional and vasogenic edema.

(C) The beneficial effects of corticosteroids in animals with traumatic brain injury is associated with its potential to act as a free-radical scavenger.

(D) Corticosteroids in any shape or form are contra-indicated in animals with traumatic brain injury.

The correct answer is D.

3. Why are corticosteroids recommended in animals with hydrocephalus?

(A) By decreasing the rate of cerebrospinal fluid production.
(B) By decreasing the inflammatory component associated with hydrocephalus.
(C) By decreasing the immune-mediated component associated with hydrocephalus
(D) By decreasing the formation of cytotoxic edema associated with hydrocephalus

The correct answer is A

4. Why are corticosteroids used in animals with brain tumors, such as intracranial meningioma?

(A) To decrease inflammation associated with the tumor
(B) To decrease vasogenic oedema associated with the tumor
(C) To decrease the rate of cerebrospinal fluid production
(D) To decrease the likelihood of metastases

The correct answer is B.

5. What is the most important factor that affects quality of life of patients treated for steroid responsive meningitis arteritis?

(A) Incomplete resolution of clinical signs
(B) Delayed response to treatment
(C) Corticosteroid-related adverse effects
(D) Relapse of clinical signs

The correct answer is C.

The difference between CT and MRI for clinical practitioners …and how to start interpretation

Royal Veterinary College
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The difference between CT and MRI for clinical practitioners

…and how to start interpretation

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1

Introduction

- Veterinary medicine has dramatically advanced in recent years
- Development of veterinary specialists and veterinary specialty hospitals
- Increased availability of advanced diagnostic modalities and treatment options
- Increased availability and demand for computed tomography (CT) and magnetic resonance imaging (MRI) for veterinary patients

RVC

2

Aims of this course

- Learn which cases will benefit from advanced imaging
- Should you consider CT or MRI?
- How to make sense from CT/MRI studies and imaging reports
- We will NOT focus on:
  - Physics involved in CT and MRI
  - Technical specificities of CT and MRI
  - Technical parameters on how to perform CT and MRI

RVC

3

Aims of this course

- 6 separate online modules:
  - One 1-hour webinar per month
  - 1st or 2nd Friday of each month
  - Introduction to CT and MRI *(today)*
  - CT and MRI in the trauma patient *(May)*
  - CT and MRI in acute spinal disease *(June)*
  - CT and MRI in chronic spinal disease *(July)*
  - CT and MRI in brain disorders part I *(August)*
  - CT and MRI in brain disorders part II *(September)*

RVC

4

Introduction

- The role of clinical assessment
- Diagnostic options in first opinion practice
  - Radiography and myelography
- Advanced diagnostics or multiplanar imaging techniques
  - Computed tomography (CT-scan)
  - Magnetic resonance imaging (MRI-scan)

RVC

5

Case 1 - Bertie

3-years-old male Dachshund
Spinal pain and reluctance to jump since yesterday

Which further diagnostics would you consider?

RVC

6

Case 1 - Bertie

- Neurological examination is suggestive for a lesion affecting the T3-L3 spinal cord segments
- Clinical assessment revealed acute onset and thoracolumbar spinal pain in a young miniature Dachshund
- Bertie's clinical presentation is very suggestive for Type I intervertebral disc extrusion
  - Medical treatment can be considered in ambulatory dogs with minimal neurological deficits
  - Diagnostic imaging can be postponed until Bertie becomes a surgical candidate

RVC

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Role of clinical assessment

- Not all neurology patients need to be referred to a neurology specialist
- Not all cases referred to a Neurology specialist require a CT or MRI scan
- Not all Neurology patients need further diagnostic investigations

RVC

8

Clinical reasoning in veterinary neurology

- What is the problem of the animal?
- Is this caused by a neurological problem?
- Where in the neurological system is the problem localized?
- What are your 2 or 3 most likely differential diagnoses?
- What is the best diagnostic test to confirm your most likely diagnoses?

RVC

9

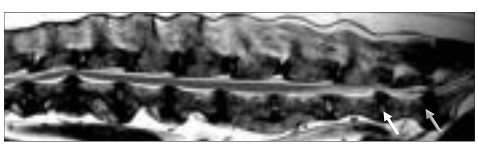
Clinical reasoning in veterinary neurology

- It is wrong to assume that every neurology patient requires a CT or MRI scan
- The need and type of further diagnostics will be determined by your most likely differential diagnoses

RVC

10

Even the most advanced diagnostics cannot replace clinical assessment!!



•Which imaging finding is clinically relevant?

•Diagnostic tests *NEVER* replace clinical assessment

RVC

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Introduction

- The role of clinical assessment
- Diagnostic options in first opinion practice
  - •Radiography and myelography
- Advanced diagnostics or multiplanar imaging techniques
  - •Computed tomography (CT-scan)
  - •Magnetic resonance imaging (MRI-scan)

RVC

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Survey radiographs

- Sometimes diagnostic
  - No further diagnostics necessary
- Sometimes supportive/suggestive
  - Further diagnostics necessary to confirm diagnosis
- Sometimes misleading
  - Spectacular radiographic abnormalities can be present in neurologically normal animals

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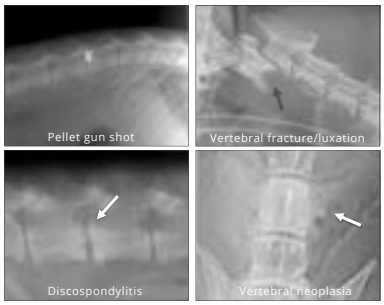
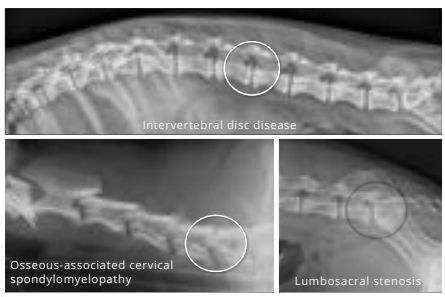
Survey radiographs – sometimes diagnostic



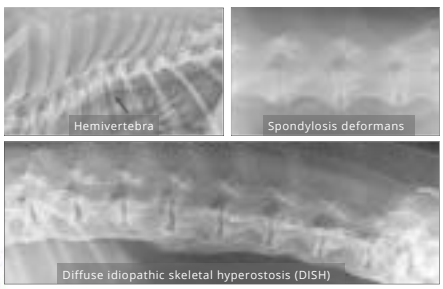
14

Survey radiographs – sometimes suggestive



15

Survey Radiographs – Sometimes misleading



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Limitations survey radiographs

- Good quality spinal radiographs require general anaesthesia or sedation, and can be time consuming

Spinal cord not visualized by survey radiographs

- Spinal cord compression present without any radiographic abnormalities
- Spectacular radiographic abnormalities not always associated with spinal cord compression

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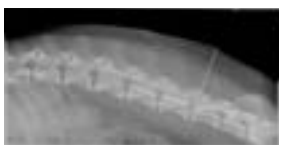
Myelography



- Intrathecal injection non-ionic contrast medium (iohexol):
  - 0.3-0.5 ml/kg for iohexol 240
- Atlanto-occipital or lumbar L5-L6 interarcuate space
- Lumbar injection technically more demanding, but safer
- If CSF-analysis desired, should be done before contrast injected in subarachnoid space

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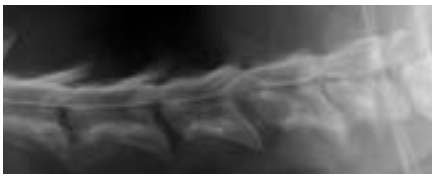
Myelography



- Extradural disc-associated compression C5-C6, while obvious radiographic abnormalities C6-C7
- Disc-associated cervical spondylomyelopathy *("wobbler syndrome")*

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Disadvantages myelography

- *Invasive diagnostic procedure!!*
  - *Postmyelographic seizures*
    - Especially in large breed dogs with cervical injections
  - *Neurological deterioration after myelography*
  - Infection, anaphylactic reaction, cardiac arrest,....
- Technically challenging and expertise required for myelography interpretation
- Not the most sensitive diagnostic technique:
  - Especially insensitive for intraparenchymal lesions

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Re-opening the window on fenestration as a treatment for acute thoracolumbar intervertebral disc herniation in dogs

Myelography, although often diagnostic, is fast becoming of historic interest only.

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Computed tomography (CT) and magnetic resonance imaging (MRI)

Multiplanar imaging techniques

22

Transverse, sagittal and dorsal planes

(De Decker S, Clinical Neurology guide for the veterinary practitioner, 2023)

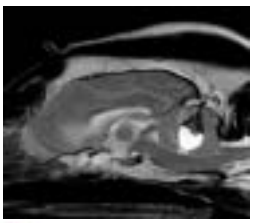
23

Comparison CT and MRI

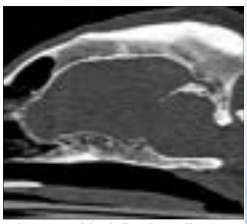
Computed tomography	Magnetic resonance imaging
More widely available	Not widely available
Less expensive	Expensive
Rapid scanning times	Longer scanning times
Excellent for bony structures	Excellent for soft-tissue structures
• Vertebra and skull	• Spinal cord and brain
Reconstruction necessary for multiplanar imaging	Direct multiplanar imaging
Multidisciplinary imaging tool	Almost exclusively used for neurology

24

MRI excellent for brain *parenchyma* and CT for the *bony* skull



Brain can be readily visualised on this sagittal MR image. It is difficult to follow the contour of the skull

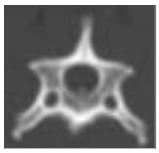


The contour of the skull can be readily followed on this sagittal reconstruction (bone window). It is difficult to identify any parenchymal brain structures

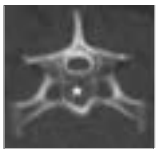
25

Spinal cord *NOT* visualised on CT

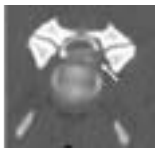
Visualisation of the spinal cord on CT requires the injection of intrathecal contrast medium to create a CT-myelogram



Computed tomography. Spinal cord is not visible



CT-myelography. Spinal cord visualised by injecting intrathecal contrast medium



CT-myelography in dog with extradural spinal cord compression

Although lower dose of contrast required than for conventional myelography, still potential for similar complications

26

Comparison CT and MRI

- *MRI superior for most spinal and brain conditions*
- CT superior for selected pathology, including traumatic brain injury and vertebral fracture/luxation
- MRI and CT have similar diagnostic value for acute and mineralized intervertebral disc extrusions
- CT can be valuable alternative for MRI in selected cases
- MRI and CT can give complementary information
- Personal experience:
  - *CT can be very useful for diagnosing spinal and brain disorders, but appropriate case selection is of major importance*

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Comparison MRI and CT

- Superior sensitivity of MRI can occasionally become a disadvantage:
  - Over-interpretation of clinically irrelevant findings
  - Age-related degenerative processes
  - Intervertebral disc degeneration, bulging and even spinal cord compression can be part of normal ageing process
  - *Intervertebral disc degeneration should not be considered a disease or diagnosis!!*

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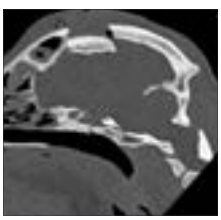
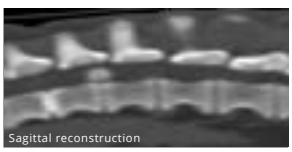
CT superior for traumatic brain injury

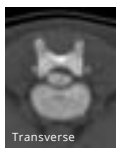


Comminuted Depressed skull fracture frontal bone

29

Similar diagnostic value for acute, Hansen type I, intervertebral disc extrusion

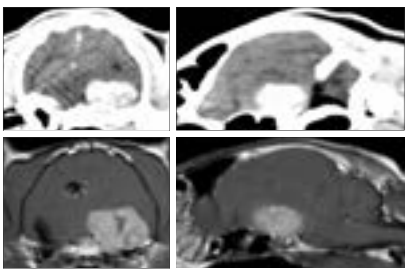




30

CT can be valuable alternative for MRI in selected cases

Intracranial meningioma readily visible on both CT and MRI



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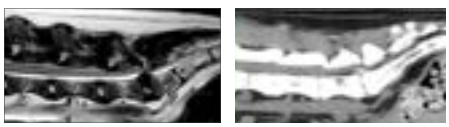
CT can be valuable alternative for MRI in selected cases

Agreement between computed tomography, magnetic resonance imaging, and surgical findings in dogs with degenerative lumbosacral stenosis

(J Am Vet Med Assoc 2006;229:1924-1929)



- Good agreement between CT and MRI
- CT can be used to diagnose degenerative lumbosacral stenosis

RVC

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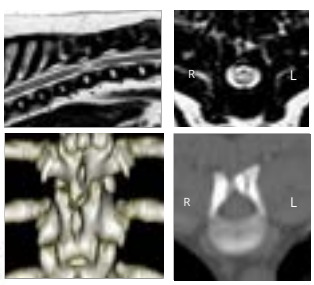
CT and MRI can give complementary information



Pug with articular process aplasia

- MRI reveals and intraparenchymal hyperintensity, which is not visible on CT. This hyperintensity is suggestive for gliosis or edema
- CT reveals a potential underlying cause, which is an absent right articular process (arrows). This was not immediately identified on MRI

RVC

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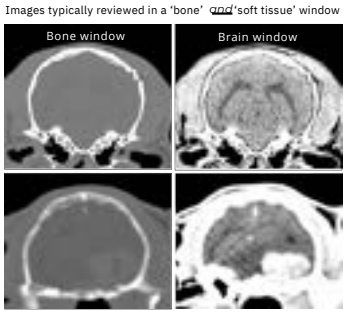
What about the different CT windows?

Images typically reviewed in a 'bone' and 'soft tissue' window



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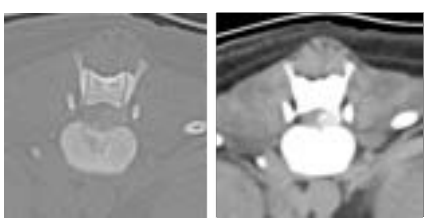
Intervertebral disc extrusion often better identified on soft-tissue window



Bone window | Soft-tissue window

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Single slice vs. multiple slice CT

- Single slice: one image per rotation
- Multiple slice: multiple images per rotation
- Most CT scanners are now multiple slice
- 4, 16, 64 slice CT scanners becoming more common
- RVC: 320 slice CT

RVC

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Single slice vs. multiple slice CT

- Advantages multiple slice CT scanner:
  - Quality improves when slice number increases
  - Faster diagnostic studies
  - Lower radiation dose
  - More specialist applications
- Disadvantage multiple slice CT scanner:
  - Expensive

Single slice

Multiple slice

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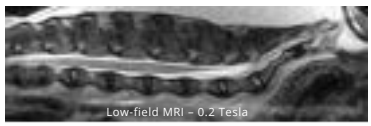
What about low-and high field MRI?



- High-field more expensive in purchase and maintenance
- High-field better image 'resolution' and higher field of view (FOV)
- Not necessarily different diagnostic value

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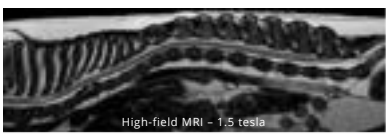
Improved image quality with increased magnet strength



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How to talk CT or MRI?

Well-demarcated, large, round, homogenous T2-weighted/FLAIR iso –to hyperintense and T1-weighted hypointense, extra-axial mass lesion, located in the left occipital lobe associated with mild to moderate perilesional edema, severe mass effect, skull erosion, and uniform contrast enhancement

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How to talk CT or MRI

Computed Tomography

- A bright/white lesion is called *hyperattenuating* or *hyperdense*
- A dark lesion is called *hypoattenuating* or *hypodense*
- A lesion with the same density as surrounding tissue is called *isodense*

Magnetic resonance imaging

- A bright/white lesion is called *hyperintense*
- A dark lesion is called *hypointense*
- A lesion with the same intensity as surrounding tissue is called *isointense*

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What about the different MRI sequences

T2-weighted and T1-weighted are the two standard sequences

T2- Weighted	T1 - Weighted
Fat = hyperintense	Fat = hyperintense
Fluid = hyperintense	Fluid = hypointense
Bone = hypointense	Bone = hypointense
Mineralised tissue = hypointense	Mineralised tissue = hypointense

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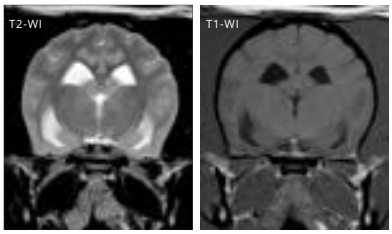
Difference T2 –and T1-weighted sequences



Fluid is hyperintense (bright) on T2-weighted and hypointense (dark) on T1-weighted images

43

Important extra sequences

- Fluid attenuation inversion recovery (FLAIR):
  - Suppresses signal from free fluid
  - Fluid filled structures, such as the lateral ventricles or cystic structures will be hypointense (dark) on FLAIR
- Contrast enhanced studies
  - Gadolinium based contrast injected IV
  - Typically used in combination withT1-weighted sequences
  - Structures outside the blood-brain-barrier take up contrast
    - Certain pathologies (inflammatory, neoplasia) can take up contrast = contrast enhancement
  - Certain anatomical structures will always take up contrast:
    - meninges, choroid plexus, pituitary gland, trigeminal nerve
  - Contrast enhancement appears hyperintense (bright) on MRI

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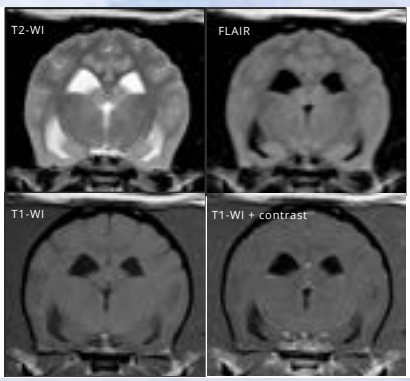
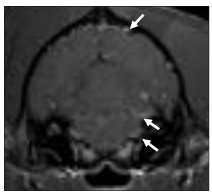
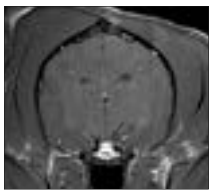


45

Certain anatomical structures always take up contrast



Meninges, choroid plexus, trigeminal nerve



Pituitary gland

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Tips for MRI interpretation

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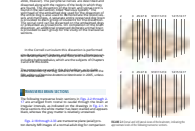
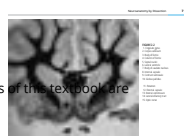
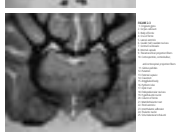
Knowledge of anatomical structures

The neuroanatomic components of this textbook are





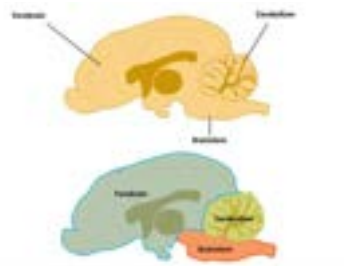


Chapter 2 – Neuroanatomy by Dissection: de Lahunta A: *Veterinary Neuroanatomy*

, 2008, Saunders Elsevier

48

Basic knowledge anatomical structures



RVC

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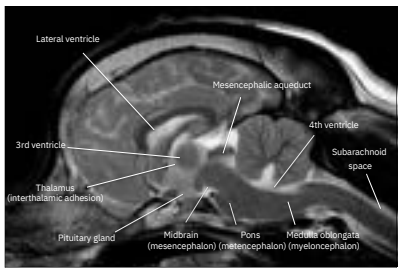
Basic knowledge anatomical structures

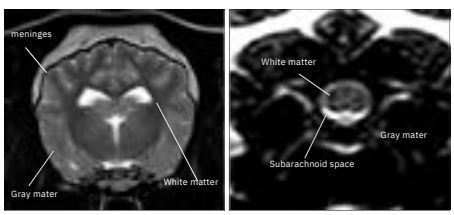


RVC

50

Basic knowledge anatomical structures

Meninges, gray matter and white matter



Gray matter is localized 'peripheral' in the brain and 'central' in the spinal cord

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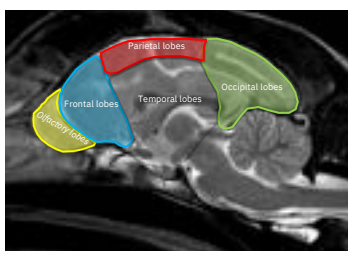
Basic knowledge anatomical structures



RVC

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Tips for MRI interpretation

- Most pathology is associated with increase in water cont ent
  - Most pathology will be clearly visible *(hyperintense)* on T2WI, while less or not visible on T1WI *(hypo –or isointense)*
- Normal anatomy, especially bones and muscle are better visualised on T1WI

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Tips for MRI interpretation

- Start by using T2-weighted sequence to search or 'screen' for pathology
- Get more information about the lesion and anatomy with T1-weighted sequence
- Use then the FLAIR and T1-weighted post contrast for better lesion characterisation
- Consider even more specialized sequences

RVC

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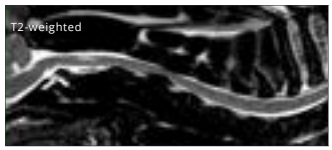

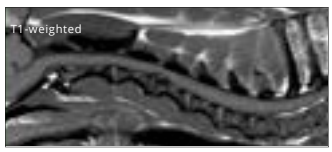

Pathology easier identified on T2-weighted images, but anatomy is better delineated on T1-weighted images

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Tips for MRI interpretation – use a checklist!

- *For brain:*
  - Ü Intra-axial or extra-axial?
  - Ü Intensity of the lesion?
  - Ü Lesion sharply demarcated?
  - Ü Anatomical location of the lesion
  - Ü Perilesional edema present?
  - Ü Mass effect present:
    - Midline shift, brain herniation
  - Ü Contrast enhancement present?
    - None, peripheral or homogenous contrast uptake
  - Ü Surrounding tissues
    - Skull, middle ear, muscle

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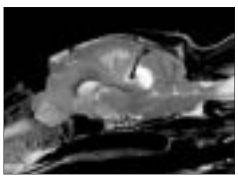
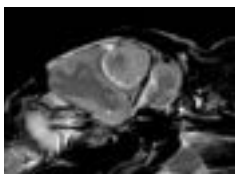
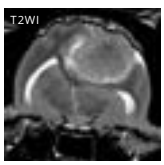
Tips for MRI interpretation

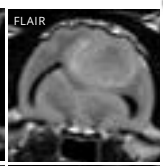


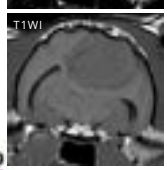


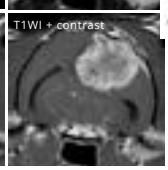
'Screen' the T2-weighted images for presence of a pathology

57









Characterise the lesion further with the other sequences

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Tips for MRI interpretation

Well-demarcated, large, round, homogenous T2-weighted/FLAIR iso –to hyperintense and T1-weighted hypointense, extra-axial mass lesion, located in the left occipital lobe associated with mild to moderate perilesional edema, severe mass effect, skull erosion, and uniform contrast enhancement

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Tips for MRI interpretation – use a checklist!

For spine:

- Ü Extradural, intradural, or intramedullary
- Ü Spinal cord compression present?
- Ü Intensity of the lesion?
- Ü Lesion sharply demarcated?
- Ü Anatomical location of the lesion
- Ü Intensity intervertebral disc?
  - Ü Decreased intensity suggestive for degeneration
- Ü Surrounding tissues
  - Ü Paraspinal musculature

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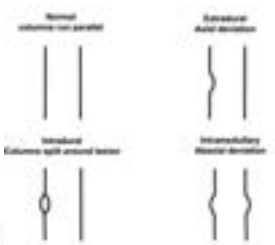
Extradural, intradural or intramedullary lesion?



- Lesions can be located in the extradural space, intradural or intramedullary
- Originates from myelographic studies
- Potentially more difficult to recognise different patterns on MRI

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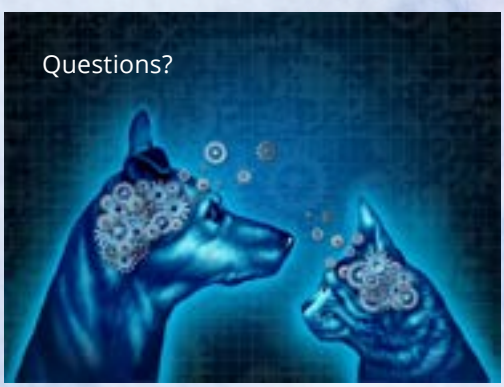

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HOW TO PERFORM A NEURO EXAM IN PRACTICE ?

Royal Veterinary College
University of London

CT and MRI in acute spinal disorders

Steven De Decker
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Professor and Head Neurology and Neurosurgery
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1

Introduction

- Acute spinal disorders are common neurological emergency
- MRI is superior for most spinal disorders
- CT can be considered in selected spinal disorders
- Patient selection is crucial!!
- Spinal fracture and luxation was discussed in previous webinar

2

Case 1 – "Dave"

- 3years and 10 months old Miniature Dachshund
- Was painful 4 days ago
  - Spontaneous yelping when picked up
  - Pain on palpation of the spine
- Not interested to go for a walk 3 days ago
- Started to have difficulties walking 2 days ago
- His pain has improved, but his gait abnormalities have det er i or at ed
- He cannot longer use his pelvic limbs since this morning

3

Case 1 - Dave

4

Neuro exam:

1. Mentation/behaviour: Normal mentation and behaviour. Dave is bright, alert and responsive
2. Gait/posture: non-ambulatory paraparesis to paraplegia
3. Proprioception: absent proprioception in both pelvic limbs
4. Cranial nerves: intact (not shown in video)
5. Spinal reflexes: unremarkable. Intact patella and withdrawal reflexes. Cutaneus trunci cut-off thoracolumbar junction
6. Spinal palpation: historical spinal pain
7. Pain perception: not tested. Assumed to be intact

5

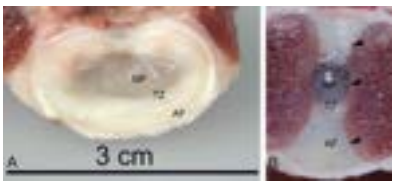
- acute onset, symmetrical, painful, progressive, T3-L3 myelopathy in a young chondrodystophic breed

Acute intervertebral disc extrusion is most likely differential

Type I intervertebral disc disease

6

Imaging characteristics normal intervertebral disc

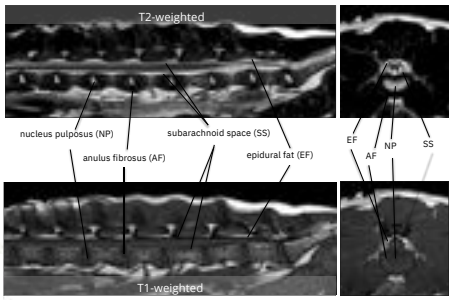


(Bergknut et al., Vet J, 2013)

- Nucleus pulposus is gelatinous, hydrated structure
  - Surrounded by fibrous anulus fibrosus
- Remember signal characteristics of fluid, fat and bone on T2 and T1-weighted images?

7

Imaging characteristics normal intervertebral disc



8

Intervertebral disc degeneration

- Intervertebral disc degeneration characterized by dehydration
- Nucleus pulposus loses 'fluid' content
- Gradual loss of T2-weighted hyperintense signal nucleus pulposus:
  - Hydrated/normal nucleus pulposus
  - Partial intervertebral disc degeneration
  - Complete intervertebral disc degeneration

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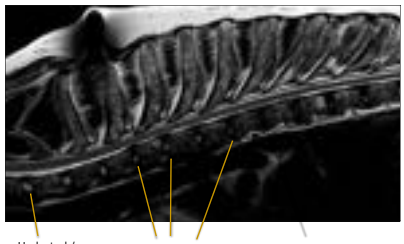
Intervertebral disc degeneration



10

Grading systems developed to classify intervertebral disk degeneration

11

Intervertebral disk degeneration does not equal intervertebral disk disease!!!

- Intervertebral disk degeneration should not be considered a disease process in itself
- Occurs commonly without development clinical signs
- Part of normal physiological ageing process
- Widespread in young, neurologically normal chondrodystrophic dogs

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Degenerative intervertebral disk disease

- Herniation of degenerate intervertebral disk
- Hansen Type I and Type II intervertebral disk disease
  - Intervertebral disk extrusion (Type I)
  - Intervertebral disk protrusion (Type II)
- Type and Type II intervertebral disk disease associated with different:
  - Pathology
  - Clinical presentation
  - Imaging characteristics
  - Surgical techniques
  - Outcome?

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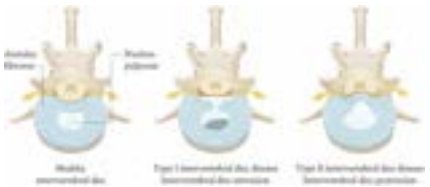
Type I and Type II intervertebral disc disease



(De Decker S, Clinical Neurology guide for the veterinary practitioner, 2023)

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Type I and Type II intervertebral disc disease represent two distinct disease entities?

Type I intervertebral disc disease	Type II intervertebral disc disease
Intervertebral disc extrusion	Intervertebral disc protrusion
Extrusion calcified nucleus pulposus	Protrusion weakened annulus fibrosus
Contusion and compression spinal cord	Compression spinal cord
Acute onset	Chronic onset
Rapid progression possible	Slowly progressive
Severe neurological dysfunction possible	Most often ambulatory at time of presentation
Chondrodystrophic breeds	Non-chondrodystrophic breeds
Young dogs (3-7 years old)	Older dogs (>9 years old)

(Type II intervertebral disc disease will be discussed in next webinar)

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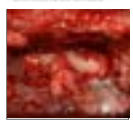
Type I intervertebral disc disease

- Nucleus pulposus is primary target of pathology
- Dehydration, mineralization and calcification nucleus pulposus
- Acute extrusion through fully ruptured anulus fibrosis
- Extruded material is mineralized and cal ci f i ed:
  - Imaging characteristics similar to bone
  - Type I intervertebral disc disease can be diagnosed by MRI and CT



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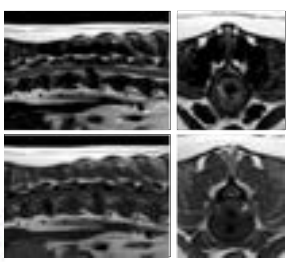
Type I intervertebral disc disease associated with hypointense extradural material on both T2 and T1-weighted sequences



- Complete intervertebral disk degeneration
- Intervertebral disc space narrowing
- Hypointense material in vertebral canal
- Spinal cord compression (loss of hyperintense CSF signal)
- Compressive material often overlying intervertebral disc space
- Often lateralized on transverse images
- Material often exceeds boundaries intervertebral disc space

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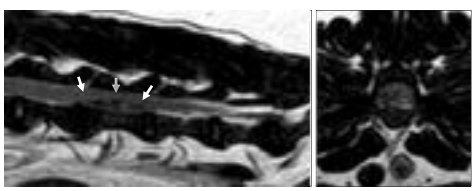
Hypointense material often lateralized and exceeds boundaries intervertebral disc space



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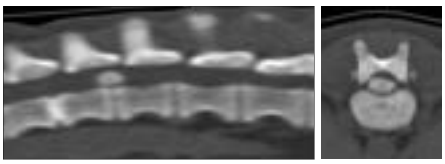
Mineralized and calcified material easily identified on CT



- Importance of case selection!! CT valuable diagnostic technique for type I intervertebral disc disease Material becomes more
- hyperdense/hyperattenuating when extruded material becomes more calcified
- Chronic extrusion more hyperdense compared to acute extrusion

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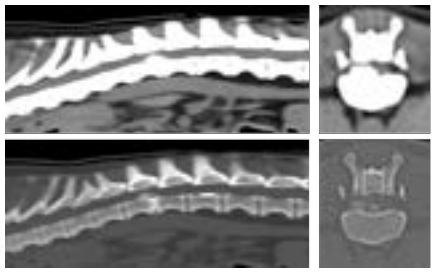
Extruded material often better observed on soft-tissue window compared to bone window



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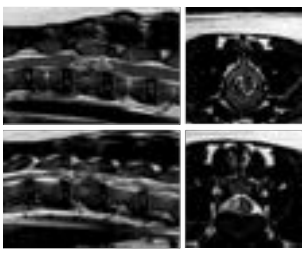
What is your diagnosis?



- 3 year Male neutered French Bulldog
- Acute onset, rapid progressive paraplegia
- Progresses from ambulatory paraparesis to paraplegia in three hours time

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CLINICAL, PATHOLOGIC, AND MAGNETIC RESONANCE IMAGING CHARACTERISTICS OF CANINE DISC EXTRUSION ACCOMPANIED BY EPIDURAL HEMORRHAGE OR INFLAMMATION

Internal vertebral venous plexus

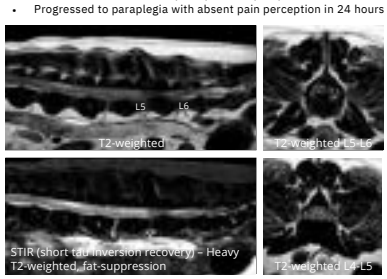
22

Prevalence and clinical features of thoracolumbar intervertebral disc-associated epidural hemorrhage in dogs

23

What is your diagnosis?

- 4-year-old French Bulldog
- Acute onset spinal pain and paraparesis
- Progressed to paraplegia with absent pain perception in 24 hours



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Progressive myelomalacia

- Ascending descending myelomalacia
- Devastating complication
- Progressive cranial/caudal hemorrhagic spinal cord necrosis
- Occurs often after surgery has already been performed
- Hopeless prognosis
- Fatal in many cases
- 10 –17.5% of dogs with Type I intervertebral disc disease presenting with paraplegia and loss of pain perception (33% of French bulldogs?):

RVC

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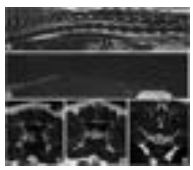
Imaging characteristics progressive myelomalacia

- Severe spinal cord swelling
  - Heavily T2-weighted sequences (Haste/myelo)
- Diffuse parenchymal hyperintensity on T2-weighted images over several spinal cord segments
- Areas of T2-weighted hypointensity possible *(cfr. Hemorrhage)*
- Hyperintensity centered in gray matter
- FLAIR sequence: hyperintensity
- T2* sequence: possible signal void



RVC

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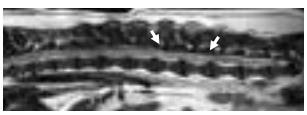
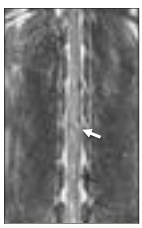
Progressive myelomalacia





- MRI characterised by extensive, poorly demarcated intraparenchymal lesion with mixed heterogeneous intensity

RVC

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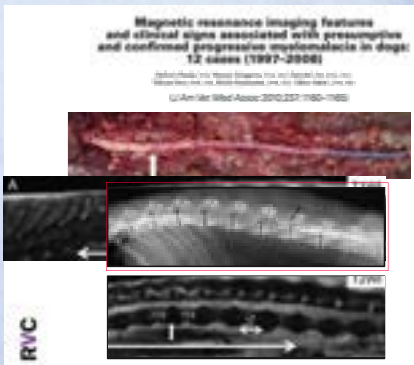

RVC

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Can MRI predict the prognosis in patients with type I intervertebral disc disease?

- Prognosis largely determined by severity clinical signs
- Degree of spinal cord compression is not associated with outcome
- Length of diffuse spinal cord hyperintensity predictive for progressive myelomalacia?
  - Inconsistent reports
  - 6 times length of L2 vertebral body?
  - 4.57 times length L2 vertebral body?
  - Loss of CSF signal on Haste (myelo) sequences 7.4 times L2 vertebral body?
  - Progressive myelomalacia can also occur without evidence of intraparenchymal hyperintensity

RVC

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Case 2 - Poppy

- 7-year-old, female spayed, labrador retriever cross
- Complete fine yesterday morning when she went into the garden
- Noticed a squirrel, which had to be chased out of the garden
- Screamed and could no longer use her pelvic limbs
- Some motor function has potentially returned in her right pelvic limb

RVC

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Case 2 - Poppy

Peracute onset, symmetrical, improving(?), non-painful, T3-L3 myelopathy in a 7-year old Labrador retriever

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Case 2 - Poppy

- Identifying most likely diagnosis is important to select most appropriate diagnostic technique
- Two top differentials for peracute onset pelvic limb paralysis:
  1. *Acute non-compressive nucleus pulposus extrusion (ANNPE)*
  2. *Ischemic myelopathy (fibrocartilaginous embolism)*
- Both conditions associated with:
  - Peracute onset
  - Non-progressive clinical signs
  - Non-painful
  - Can be symmetrical or strongly lateralized
  - Non-chondrodystrophic breeds
  - Middle-aged to older
  - Strenuous activity
  - ANNPE can also occur after external trauma

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MRI scan Poppy

Acute non-compressive nucleus pulposus extrusion (ANNPE)

Other names: high-velocity, low-volume disc extrusion and traumatic intervertebral disc extrusion

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Acute non compressive nucleus pulposus extrusion

- Specific type of intervertebral disc extrusion
- Extrusion small amount non-degenerate nucleus pulposus
- Nucleus pulposus retains hydrated status
- Consider imaging characteristics non-degenerate, hydrated nucleus pulposus
- Spinal cord contusion without compression

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Imaging characteristics acute non compressive nucleus pulposus extrusion

- *Diagnostic MRI criteria:*
  1. Focal T2W hyperintensity overlying intervertebral disc space
  2. Homogenously hyperintense/hydrated nucleus pulposus signal
  3. Smaller volume nucleus pulposus
  4. Narrowed intervertebral disc space
  5. Possible small amount of extruded material in epidural space
- *Computed tomography not associated with specific abnormalities:*
  - Narrowed intervertebral disc space
  - Value in excluding spinal fracture and luxation after external trauma

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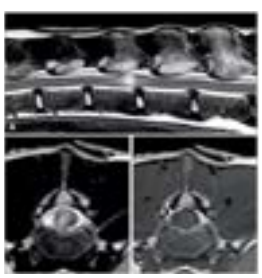
MRI characteristics of acute non-compressive nucleus pulposus extrusion



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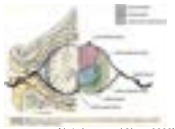
Ischaemic myelopathy

- Vascular disease of spinal cord
- Peracute occlusion spinal vasculature
- Ischemia spinal cord parenchyma
- Fibrocartilaginous embolism:
  - Sudden *embolization spinal cord blood vessel* by fibrocartilaginous tissue identical to nucleus pulposus
- Diagnostic imaging might reveal area of ischemia
  - Ischemia results in cytotoxic edema
  - Cytotoxic edema associated with higher fluid content
  - Cfr. Imaging characteristics fluid



(de Lahunta and Glass, 2009)

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Imaging characteristics ischemic myelopathy

- *Magnetic resonance imaging:*
  - Can be normal in very early stage
  - Linear, poorly demarcated, intraparenchymal T2W hyperintensity
  - Might be centered in grey matter
  - Possible spinal cord swelling
  - Typically not contrast enhancing
  - Mild contrast enhancement can be seen in later stages:
    - § Neovascularisation?
- *Computed tomography:*
  - No specific abnormalities

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MRI diagnosis ischemic myelopathy based on observation T2W linear hyperintensity spinal cord parenchyma

Hyperintensity centered in grey matter

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Can MRI reliably differentiate between ANNPE and ischemic myelopathy?

Assessment of Interobserver agreement and use of selected magnetic resonance imaging variables for differentiation of acute noncompressive nucleus pulposus extrusion and ischemic myelopathy in dogs

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Can MRI reliably differentiate between ANNPE and ischemic myelopathy?

INTER- AND INTRAOBSERVER AGREEMENT FOR DIAGNOSING PRESUMPTIVE ISCHEMIC MYELOPATHY AND ACUTE NONCOMPRESSIVE NUCLEUS PULPOSUS EXTRUSION IN DOGS USING MAGNETIC RESONANCE IMAGING

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INTER- AND INTRAOBSERVER AGREEMENT FOR DIAGNOSING PRESUMPTIVE ISCHEMIC MYELOPATHY AND ACUTE NONCOMPRESSIVE NUCLEUS PULPOSUS EXTRUSION IN DOGS USING MAGNETIC RESONANCE IMAGING

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Can MRI predict the prognosis in animals with ANNPE or ischemic myelopathy?

- Prognosis predominantly determined by severity clinical signs
- *Ischemic myelopathy:*
  - Association between lesion length and severity clinical signs
  - Poor outcome associated with lesion length > 2 times L2 vertebra
  - Poor outcome associated with lesion cross sectional area >67%
- *Acute non-compressive nucleus pulposus extrusion:*
  - Poor outcome associated with larger lesion cross sectional area

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Larger lesion associated with more severe clinical signs and worse outcome in dogs with ischemic myelopathy

Lesion vertebral length > 2.0 and lesion cross sectional area >67% associated with poor outcome?

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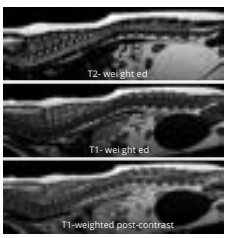
Differentiate from…



- Myelitis and meningomyelitis typically associated with contrast enhancement
- Inflammatory disorders often associated with multifocal and/or diffuse lesions

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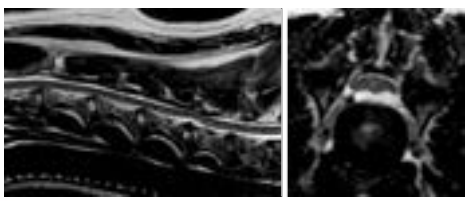
Case 3 - Tunya

- 7-years-old female spayed Doberman Pinscher
  - acute onset, non-ambulatory tetraparesis



What is your diagnosis?

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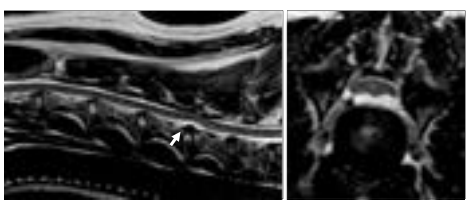
Case 3 - Tunya

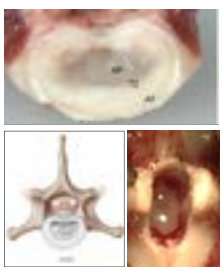


Hydrated Nucleus pulposus extrusion (HNPE)

47

Hydrated nucleus pulposus extrusion (HNPE)

- Specific type intervertebral disc extrusion
- Predilection for cervical spinal cord
- Acute onset of severe neurological deficits
- Previously called 'Discal cyst'
- *Hydrated,* non-degenerate, nucleus pulposus extrudes and causes spinal cord contusion and variable compression
- Consider imaging characteristics of hydrated or 'fluid rich' structures



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Hydrated nucleus pulposus extrusion (HNPE)

- Characteristic MRI abnormalities:
  - Reduced volume nucleus pulposus
  - Ventral, mildline, extradural, homogenously T2W hyperintense material
  - Extradural material isointense to non-degenerate nucleus pulposus in all sequences
  - Extruded material can have bilobed or "seagull appearance
  - Possible T2W hyperintensity in overlying spinal cord

RVC

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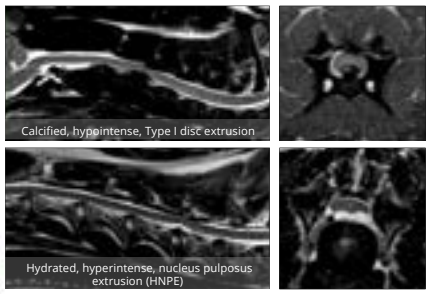
Hydrated nucleus pulposus extrusion



RVC

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Can CT be used to detect hydrated nucleus pulposus extrusion?

- Conventional CT:
  - No specific abnormalities
  - Narrowed intervertebral disc space?
- Contrast enhanced CT:
  - CT after IV injection iodinated contrast medium
  - Hypodense extradural compressive lesion with rim enhancement immediately dorsal to intervertebral disc space
  - 91% Sensitive and 100% specific to differentiate between HNPE and cervical type I intervertebral disc extrusion

RVC

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Use of contrast enhanced CT to detect hydrated nucleus pulposus extrusion

RVC

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RVC

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Use of CT-myelography to detect hydrated nucleus pulposus extrusion

Mysto-CT imaging findings in 15 dogs with surgically-treated cervical acute compressive hydrated nucleus pulposus extrusion

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Myelo-CT imaging findings in 15 dogs with surgically-treated cervical acute compressive hydrated nucleus pulposus extrusion

Characteristic findings in 13/15 dogs

Less characteristic findings in 2/15 dogs

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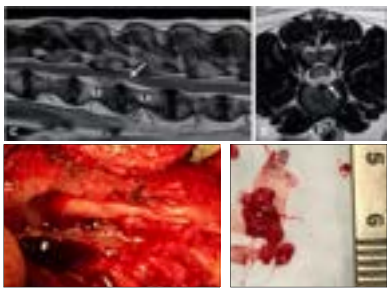
Although HNPE has a predilection for the cervical spine, it can also affect the thoracolumbar vertebral column



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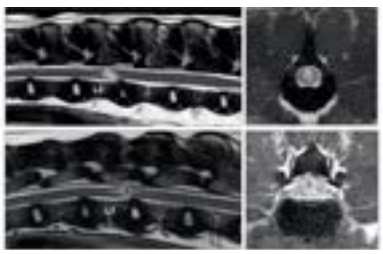
What is your diagnosis?

Case 1

Case 2



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Intradural/intramedullary intervertebral disc extrusion

- Intradural or intramedullary extrusion nucleus pulposus
- Calcified and dehydrated OR hydrated and non-degenerate
- Clinical presentation similar to Type I IVDE OR ANNPE
- Linear tract extending from disc into spinal cord parenchyma:
  - T2W hyperintense
  - T1W Iso – to hypointense
  - Signal void on T2*
- Intraparenchymal hemorrhage possible
- Mild contrast enhancement possible
- CT-myelography useful to detect dural tear
- Separate disease entity? Prognostic significance?

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Diagnostic Imaging in Intervertebral Disc Disease

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Case 4 - Drum

- 9-year-7monts old, male neutered Labrador retriever
- Presented for acute onset bilateral pelvic limb lameness of 24hours duration
- General physical examination within normal limits
- Neurological examination:
  - Stiff bilateral pelvic limb gait
  - Marked lumbosacral pain
  - No other abnormalities

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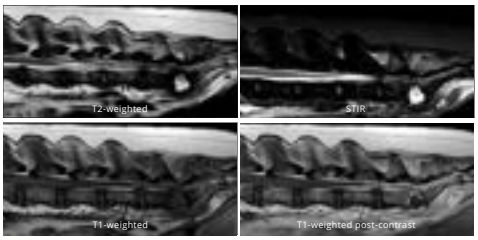
Case 4 - Drum



- Describe the abnormalities?
- What is your diagnosis?

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Discospondylitis

- Bacterial or fungal infection intervertebral disc space
- Difficult to diagnose
- Varying clinical signs
  - Acute or chronic onset
  - Vague clinical signs
  - Spinal pain with or without (variable) neurological deficits, lameness,...
  - Spinal fracture, subluxation, spinal empyema,....
  - Systemic abnormalities only present in approximately 25% of cases

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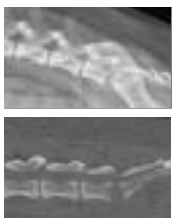
Diagnosis of discospondylitis

- *Survey radiographs:*
  - Osteolysis vertebral endplates
  - Sclerosis vertebral endplates
  - Osseous proliferation
  - Collapse intervertebral disc space
  - DELAY IN RADIOGRAPHIC ABNORMALITIES!!
- *Computed tomography:*
  - More sensitive than survey radiography
  - Earlier detection osteolytic lesions



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Diagnosis of discospondylitis

- *Magnetic resonance imaging:*
  - Imaging modality of choice in human medicine
  - More sensitive than radiography and computed tomography?
  - Affected intervertebral disc can be hyperintense on STIR and T2W
  - Affected vertebral endplates often hypo intense on T2W and T1W
  - Affected vertebral endplates often hyper intense on STIR
  - Affected vertebral bodies often T2W and T1W hypo to isointense
  - Contrast enhancement often present
  - Abnormalities in adjacent soft tissues
  - Extension of empyema

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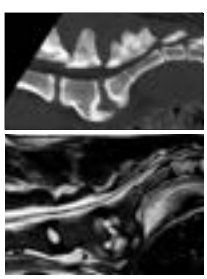
MRI more sensitive than CT?



CT and MRI studies performed on the same day

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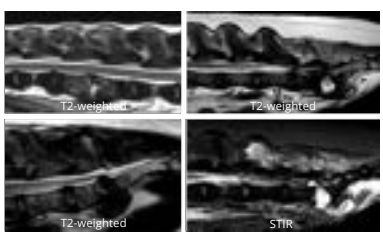
MRI characteristics of discospondylitis



- Affected intervertebral disc can be hypointense or hyperintense on T2W
- T2W and STIR hyperintense lesions can occur in adjacent soft tissues

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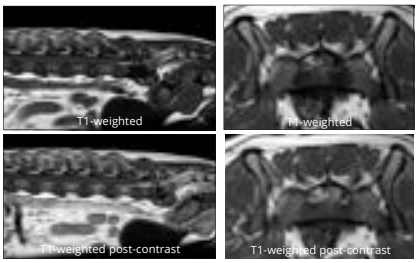
Contrast enhancement often present



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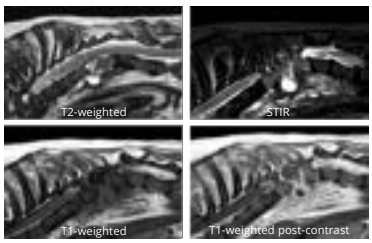
Spinal empyema associated with discospondylitis



T2W and STIR hyperintense and contrast enhancement

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Use of advanced imaging to stop treatment

- Animals with discospondylitis receive long-term antibiotic treatment (6 –18 months)
- Unclear how long treatment should be continued
- Unclear if diagnostic imaging can reliably help:
  - Diagnostic imaging findings lag behind clinical overlap
  - Overlap between imaging findings associated with infection and healing
  - No specific imaging variables associated with 'inactive; infection

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What's your diagnosis?

- 2-months-old, Male, Dogue De Bordeaux
- Acute onset lethargy, pyrexia, reluctance to walk and vocalization
- Marked pain on caudal lumbar palpation

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Physitis

- Uncommon condition
- Young dogs
- Physitis caudal vertebral physis
- Osteolysis initially restricted to caudal vertebral physis
- Progresses to collapse caudal vertebral body and spondylosis

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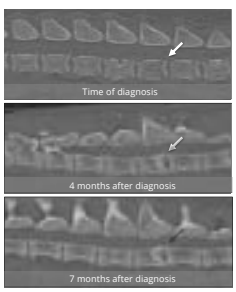
Physitis progresses from lysis caudal vertebral physis to collapse caudal vertebral body and spondylosis



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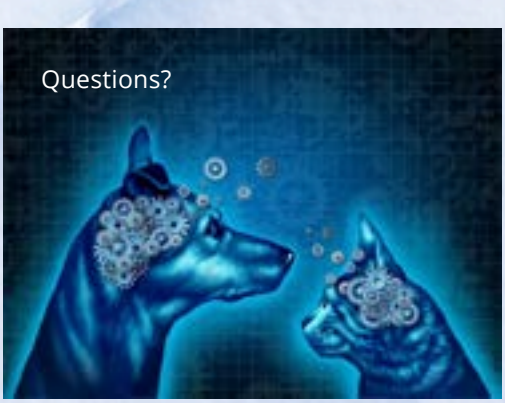
Questions?

CT and MRI in chronic spinal disorders

Royal Veterinary College
University of London

CT and MRI in chronic spinal disorders

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1

Case 1 - Dylan

- 1y9m, Male, Great Dane
- Progressive gait abnormality of 6 months duration
- Difficulties using pelvic limbs
- 'Sinks' trough pelvic limbs when standing
- Short and stiff stride thoracic limbs
- General physical examination unremarkable

2

Chronic onset, progressive, painful, symmetrical, C1-C5 myelopathy

3

Cervical Spondylomyelopathy

- Distinct clinical syndromes?
  1. *Disk-associated cervical spondylomyelopathy (DA-CSM)*
  2. *Osseous-associated cervical spondylomyelopathy (OA-CSM)*

4

Disc-associated cervical spondylomyelopathy

- Older large breed dogs *(>7 years)*
- Doberman Pinscher
- Intervertebral disk protrusion(s)
- C5-C6 & C6-C7
- Multiple sites in 25-50%

Osseous-associated cervical spondylomyelopathy

- Young-adult giant breeds *(18-36 months)*
- Great Dane, Dogues de Bordeaux
- Articular process abnormalities
- H
  Also more cranial sites
- Multiple sites in 85%

5

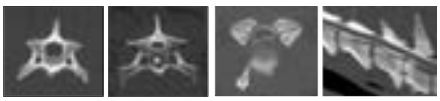
Disc-associated cervical spondylomyelopathy (DA-CSM)

- One or more caudal cervical intervertebral disk protrusions:
  - C6-C7 and C5-C7 most common affected
- Vertebral abnormalities:
  - Abnormal shape vertebral body –
    Flattening cranioventral aspect to triangular shaped
  - Abnormal position vertebral body –
    Craniodorsal tilting into vertebral column
- Mid-dorsal extradural compression:
  - Ligamentum flavum hypertrophy
- Spondylosis deformans, funnel-shaped vertebral canal

(Van Gundy, 1988)

6

Computed tomography (CT) and CT-myelography



Computed tomography (CT) | CT-myelography in an unaffected dog | CT-myelography in a dog with DA-CSM | Sagittal reconstruction

- CT gives excellent detail of bone
- Soft tissue structures, including spinal cord, not clearly visualised on CT
- CT CANNOT BE USED TO CONFIRM A DIAGNOSIS OF CERVICAL SONDYLOMYELOPATHY
- Intrathecal contrast injection necessary to visualise spinal cord à CT-myelography
- Similar safety concerns as with myelography

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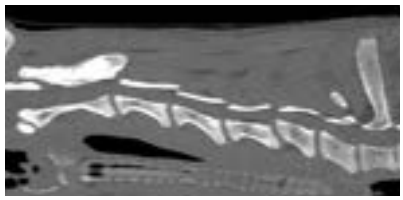
A diagnosis of DA-CSM cannot be confirmed by computed tomography



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CT and CT-m findings in Disk-associated CSM

- One or more intervertebral disk protrusions
- Narrowed intervertebral disk spaces
- Sclerosis vertebral endplates

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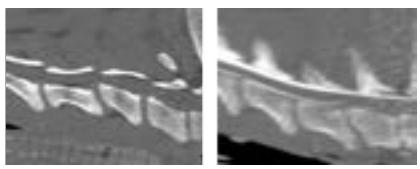
Disk-associated CSM



- Craniodorsal tilting vertebral body
- Flattening ventrocranial border vertebral body

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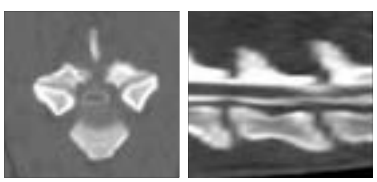
Disk-associated CSM



•Ligamentum flavum hypertrophy causing additional dorsal compression

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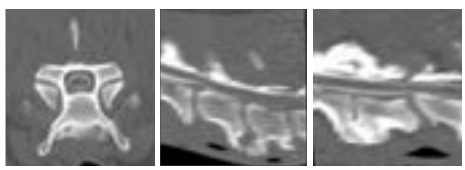
Disk-associated CSM



- Spondylosis deformans
- Not always associated with site of spinal cord compression

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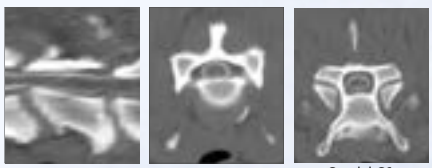
Disk-associated CSM



Sagittal C6 | Cranial C6 | Caudal C6

- Funnel-shaped vertebral canal à narrowed cranial orifice

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Diagnostic imaging in dogs with DA-CSM

- Abnormalities can be present in both ventral and dorsal contrast columns
- Dynamic studies
  - Traction
  - Flexion
  - Extension

  } Clinical value?

Dynamic studies are *ABSOLUTELY NOT* indicated when performing survey radiographs or conventional CT

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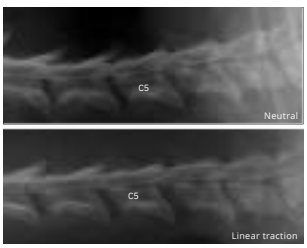
Most DA-CSM lesions are 'traction-responsive'



Controversy about definitions, standardization and factors influencing response to traction

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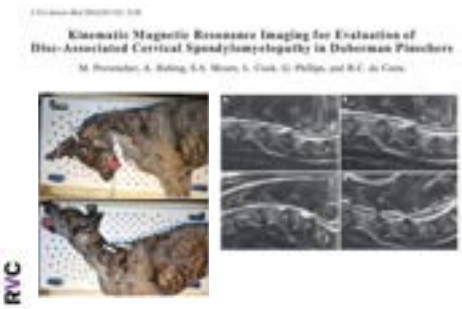
Dynamic studies also possible with CT and MRI



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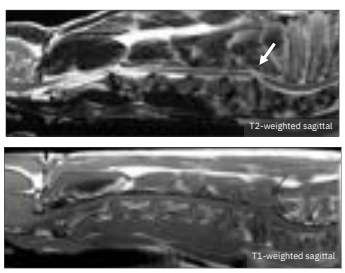
Magnetic resonance imaging (MRI) is diagnostic modality of choice



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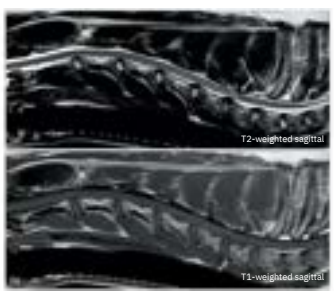
Magnetic resonance imaging is diagnostic modality of choice



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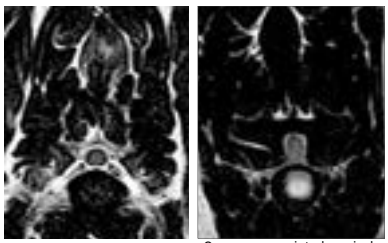
Magnetic Resonance imaging is diagnostic modality of choice



Normal

Osseous-associated cervical spondylomyelopathy

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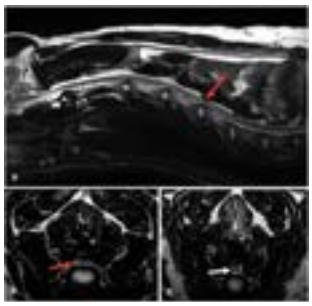
Magnetic Resonance imaging is diagnostic modality of choice



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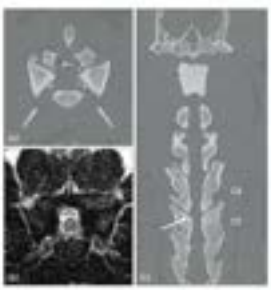
MRI and CT can give complementary information



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Remember Doug?

- 1y4m, ME, Pug
- 5 month history of progressive paresis and ataxia of the pelvic limbs
- No apparent pain
- No improvement on NSAIDs
- General physical examination unremarkable

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Chronic onset, progressive, non-painful, symmetrical, T3-L3 myelopathy

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Chronic spinal problems associated with the Pug breed

- *Hemivertebra with kyphosis*
  - Clinical signs in first year of life
- *Caudal articular process dysplasia*
- *Meningeal fibrosis and constrictive myelopathy*
  - Clinical signs later in life ('middle aged to older')
- *Spinal arachnoid diverticula*
  - Potential 'bimodal' age distribution – young or older

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Hemivertebra occur commonly in neurological normal small brachycephalic breeds

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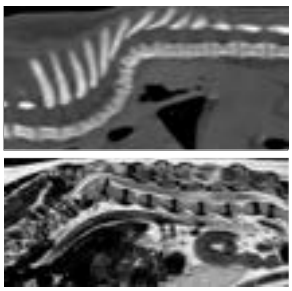
Hemivertebra with kyphosis often INCIDENTAL finding



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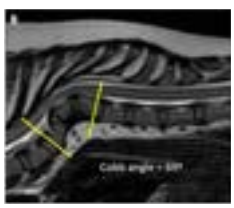
Pug breed and a Cobb angle exceeding 35 degree are associated with increased likelihood of clinical signs



Cobb angle is obtained by measuring angle between line drawn parallel to the cranial vertebral endplate of the first vertebra cranial and a line parallel to the caudal vertebral end plate of the first vertebra caudal to the hemivertebra

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Evaluation of radiography as a screening method for detection and characterisation of congenital vertebral malformations in dogs

- CT more sensitive for detection hemivertebra than radiography:
  - More vertebral malformations detected on CT compared to radiography
  - Better inter- and intraobserver agreement CT for classification hemivertebra subtypes

Hemivertebra subtypes?

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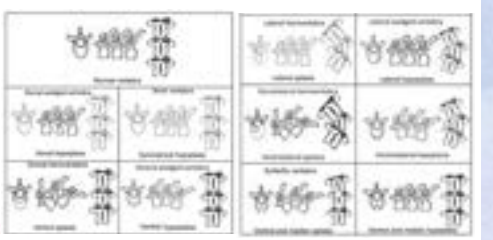
10 hemivertebra subtypes based on degree and location vertebral defect?



(De Decker, Rohdin, Gutierrez-Quintana, 2024, In Press)

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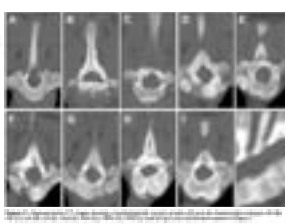
Relationship between breed, hemivertebra subtype, and kyphosis in apparently neurologically normal French Bulldogs, English Bulldogs, and Pugs

Unclear if type and number of hemivertebra is associated with clinical signs



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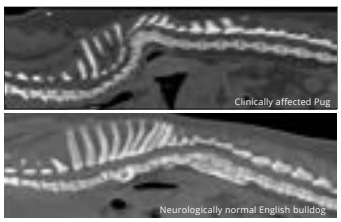
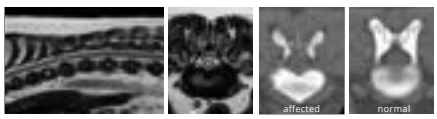
Smaller number of hemivertebra associated with neurological signs?



37

Other Pug specific vertebral anomalies?

Constrictive myelopathy secondary to hypoplasia or aplasia of the thoracolumbar caudal articular processes in Pugs: 11 cases (1993–2009)



- Absence or decreased size one or more caudal articular processes
- Low grade instability causes hypertrophy soft tissues
- Epidural circumferential constrictive fibrosis, 'constrictive myelopathy' or 'meningeal fibrosis

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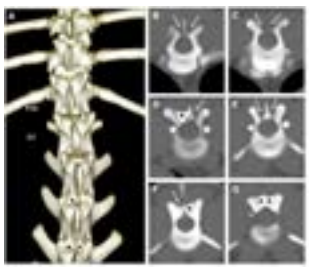
Caudal articular process dysplasia



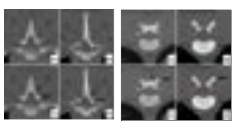
Absence or decreased size one or more caudal articular processes

39

Caudal articular process dysplasia extremely common in neurologically normal Pugs

Caudal articular process dysplasia of thoracic vertebrae in neurologically normal French bulldogs, English bulldogs, and Pugs: Prevalence and characteristics

- Caudal articular process dysplasia very common in small brachycephalic breeds:
  - 97% of Pugs
  - 70% of French bulldogs
  - 84% of English bulldogs



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Meningeal fibrosis or constrictive myelopathy

- Formation of circumferential fibrotic tissue causing intradural adhesion and progressive constriction spinal cord
- Historically associated with caudal articular process dysplasia in pugs
- Occurs however also in dogs without vertebral anomalies
- Clinical signs develop later in life
- Slow progressive clinical signs
- Urinary and fecal incontinence common

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Meningeal fibrosis or constrictive myelopathy

- CT will not reveal suggestive abnormalities
- MRI is diagnostic modality of choice:
  - Irregular subarachnoid space with mixed signal intensity on T2-weighted images
  - Multiple linear hypointense bands that transverse across the arachnoid space
  - Spinal cord distortion and compression
  - CSF in multiple pockets
  - Bilateral V-shaped ventrolateral extradural lesions

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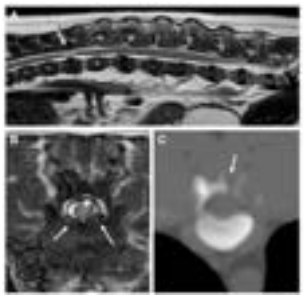
MRI is diagnostic modality of choice for meningeal fibrosis or constrictive myelopathy



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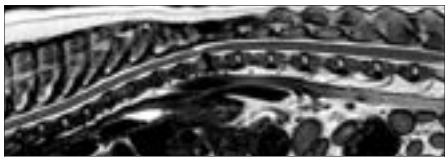
Further diagnostics in Doug the Pug



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Spinal arachnoid diverticulum

© Klinkenberg E

Spinal arachnoid diverticulum

- Focal dilatation subarachnoid space with accumulation cerebrospinal fluid
- 'Spinal arachnoid cyst', 'spinal arachnoid pseudocyst'
- Congenital and acquired forms
- Slowly progressive clinical signs
- Pain is typically not present and urinary/faecal incontinence can occur

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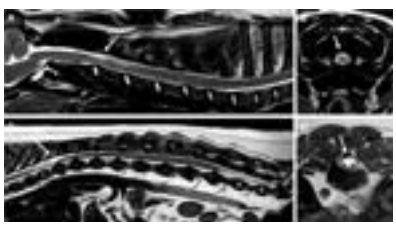
Spinal arachnoid diverticulum can occur in cervical or thoracolumbar region



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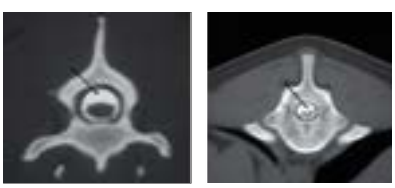
CT-myelography in dogs with spinal arachnoid diverticulum



Focal dilatation subarachnoid space with pooling of contrast medium

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Case 3 – Remember Boris

- 10-year-old, male neutered, German Shepherd dog
- 4 months history of progressive pelvic limb ataxia and weakness
- Sensitive on thoracolumbar palpation

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Chronic onset, progressive, painful, symmetrical, T3-L3 myelopathy

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Case 3 - Boris

- Multiple intervertebral disc extrusion or protrusion (Type I or II IVDD)?
- Does it matter to differentiate between extrusions and protrusions?

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Type I and Type II intervertebral disc disease

(De Decker S, Clinical Neurology guide for the veterinary practitioner, 2023)

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Type II intervertebral disc disease

- Anulus fibrosus is primary target of pathology
- Anulus fibrosus loses its physical integrity
- Nucleus pulposus can migrate dorsally into weakened anulus fibrosus
- Chronic protrusion dorsal anulus into vertebral canal
- Protruded disk has soft tissue char act er i st i cs:
  - Type II intervertebral disc disease cannot be diagnosed by CT

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Type II intervertebral disc disease cannot be diagnosed by conventional CT

Intrathecal contrast injection necessary to visualize disc-associated spinal compression

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Identifying which clinical and magnetic resonance imaging (MRI) characteristics would be most predictive for thoracolumbar IVDE or IVDP

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CLINICAL AND MAGNETIC RESONANCE IMAGING CHARACTERISTICS OF THORACOLUMBAR INTERVERTEBRAL DISK EXTRUSIONS AND PROTRUSIONS IN LARGE BREED DOGS

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Four MRI variables identified as independent predictors for IVDE or IVDP

MRI VARIABLE	INTERVERTEBRAL DISK EXTRUSION	INTERVERTEBRAL DISK PROTRUSION
Lateralized intervertebral disk herniation	More likely	Less likely
Partial loss of complete intervertebral disk degeneration	Less likely	More likely
Multiple intervertebral disk herniations	Less likely	More likely
Increased disk material confined to intervertebral disk space	Less likely	More likely

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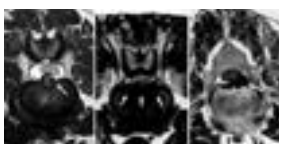
Midline intervertebral disk herniation predictive for protrusion

- Lateralized intervertebral disk herniation predictive for IVDE
- Lateral displacement chronic herniations limited by anatomical boundaries intact dorsal longitudinal ligament?



Protrusion Protrusion Extrusion

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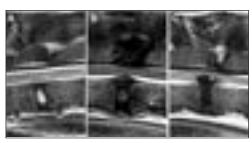
Partial intervertebral disk degeneration predictive for protrusion

- Complete intervertebral disk degeneration predictive for extrusion
- Nucleus pulposus primary target of degeneration in IVDE, while anulus fibrosus primary target of degeneration in IVDP
- Partial degeneration or partial dehydration nucleus pulposus?



Normal Protrusion Extrusion

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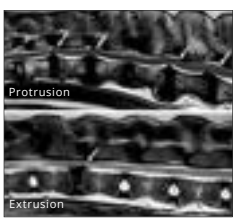
Multiple intervertebral disk herniations associated with protrusion

- Multifocal character IVDP?
- Chronic progressive herniations allows multiple disks to herniate before clinical signs occur?
- Acute IVDE less likely subclinical?
- Older age dogs with IVDP?



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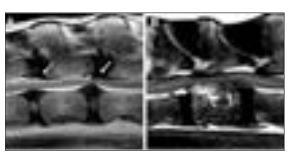
Dispersion intervertebral disk material beyond border intervertebral disk space associated with extrusion

- Intervertebral disk remains physically intact in IVDP
- Dorsal longitudinal ligament remains physically intact in IVDP



Protrusion Extrusion

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Evaluation MRI guidelines for differentiation between thoracolumbar intervertebral disk extrusions and protrusions

Observer	Degree of experience	Correct diagnoses without guidelines (out of 80)	Correct diagnoses with guidelines (out of 80)
Observer 1	Expert	69 (86.2%)	73 (91.2%)
Observer 2	Moderate	53 (66.2%)	63 (78.8%)
Observer 3	None	36 (45%)	42 (52.5%)
Observer 4	Expert	54 (67.5%)	68 (85%)
Observer 5	Moderate	71 (88.8%)	74 (92.5%)
Observer 6	None	57 (71.2%)	62 (77.5%)
Overall	NA	340 (70.8%)	382 (79.6%)

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Case 4 - Teddy

- 8-years-old male neutered Labrador retriever
- In the last 3 weeks: sifficulty jumping in the car, less interested to go for walks and difficulties to go upstairs
- Treatment with NSAIDs have resulted in temporary improvement
- Clinical signs have slowly progressed

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Case 4 - Teddy

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Chronic onset, progressive, non-painful, symmetrical, L4-S3 myelopathy

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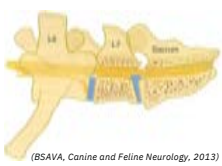
Degenerative lumbosacral stenosis

= Most common cause of cauda equina syndrome in dogs

- Multifactorial disorder
- Combination of bony and soft tissue structures causes progressive stenosis lumbosacral vertebral canal:
  - Intervertebral disc protrusion
  - Ligamentum flavum hyper t r ophy
  - Articular process hypertrophy
  - Telescoping lamina S1 into vertebral canal L7
  - Vertebral misalignment
  - Transitional vertebra
  - Lumbosacral osteochondrosis
  - Synovial cysts
  - Osteophyte formation
  - .....



(BSAVA, Canine and Feline Neurology, 2013)

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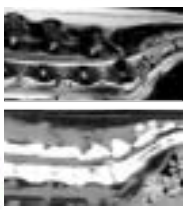
Agreement between computed tomography, magnetic resonance imaging, and surgical findings in dogs with degenerative lumbosacral stenosis

[redacted]

(J Am Vet Med Assoc 2006;229:1924-1929)



- Good agreement between CT and MRI
- CT can be used to diagnose degenerative lumbosacral stenosis

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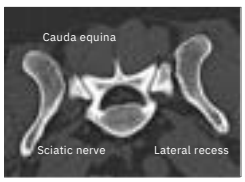
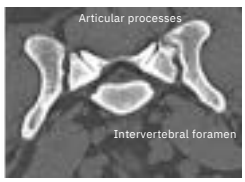
Normal CT appearance lumbosacral area



Vertebral body L7



Lumbosacral intervertebral disk space

- Epidural fat surrounds the cauda equina nerve and thecal sac, providing a natural source of soft tissue contrast

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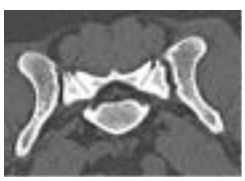
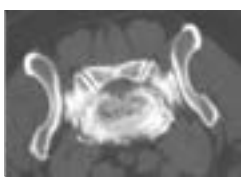
68

How to diagnose DLSS by CT?



Normal



DLSS affected

- In DLSS, epidural fat is lost:
  - à Creates a silhouetting effect
  - à Complicates differentiation compressive soft tissues and adjacent nerve tissues

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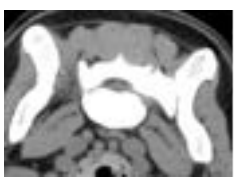
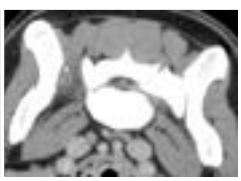
69

How to diagnose DLSS by CT?



Pre-contrast



After IV-contrast

- Intravenous contrast-enhanced CT àdiscrimination of compressive soft tissues within the vertebral canal

(Jones JC, et al., Vet Radiol Ultrasound, 1999)

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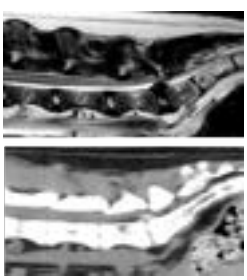
70

Diagnostic findings in animals with degenerative lumbosacral stenosis



- Predominant cause cauda equina compression often Type II intervertebral disc protrusion
- Transitional vertebrae common in dogs with DLSS
- Transitional vertebra can complicate surgery if not recognised

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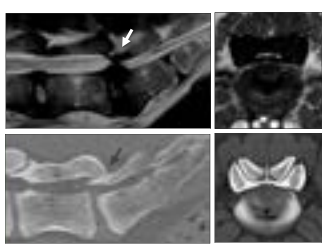
Telescoping lamina into vertebral canal L7



- Ventral compression caused by Intervertebral disc protrusion
- Transitional vertebra
- Dorsal compression caused by telescoping lamina S1 into vertebral canal L7 (arrow)

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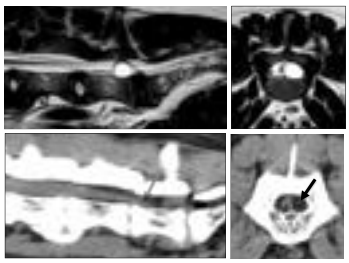
Synovial cyst in animals with degenerative lumbosacral stenosis (DLSS)



Synovial cysts originates from articular facet degeneration. Indicated by arrow on CT images

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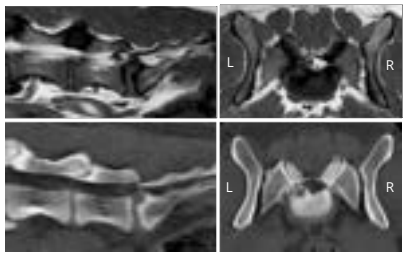
73

Diagnostic findings in animals with DLSS



Osteochondrosis (OCD) lesion of the cranial vertebral endplate of S1. Defect in the craniodorsal aspect of the vertebral endplate clearly visible. Left sided cauda equina compression.

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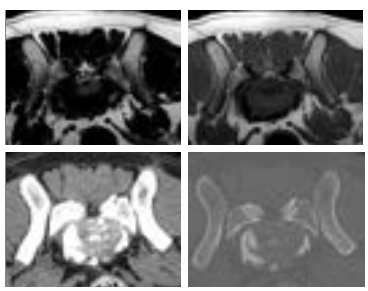
Diagnostic findings in animals with DLSS



Bilateral Foraminal stenosis

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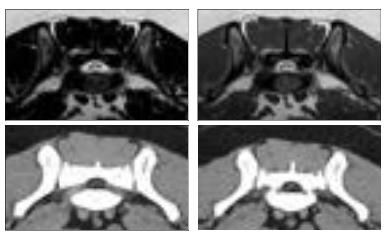
Nerve enlargement associated with foraminal stenosis



- Peripheral nerves enlarge in response to chronic compression
- Mechanical response. No contrast enhancement expected
- Do not confuse with malignant or inflammatory disease processes

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Pitfalls in the diagnosis of degenerative lumbosacral stenosis

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77

Degenerative abnormalities of the lumbosacral joint occur however frequently in clinically normal dogs

Beware of false positive diagnoses!!

Large breed dogs and....

Screw-tailed brachycephalic dogs

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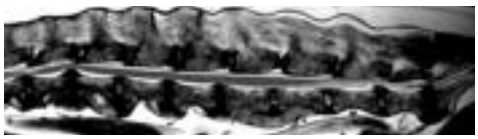
Lumbosacral abnormalities are commonly seen in older, large breed dogs without cauda equina syndrome



Poor correlation between imaging findings and clinical signs

Beware of false positive diagnoses

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SUBCLINICAL CT ABNORMALITIES IN THE LUMBOSACRAL SPINE OF OLDER LARGE-BREED DOGS

Jerry C. Jones, DVM, PhD, Karen D. Inzana, DVM, PhD

Lumbosacral abnormalities are commonly seen in neurologically normal large breed dogs

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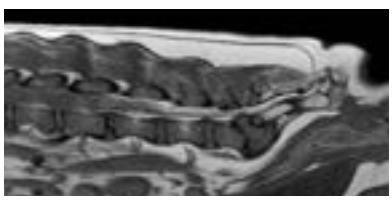
Congenital malformations of the lumbosacral vertebral column are common in neurologically normal French Bulldogs, English Bulldogs, and Pugs, with breed-specific differences



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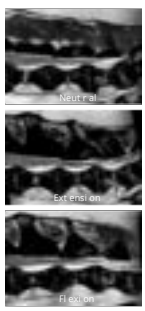
Role of dynamic imaging studies?

- Diagnostic imaging with hips in neutral, extended and flexed positions?
- Currently no evidence that 'instability' plays a role in degenerative lumbosacral stenosis
- *No evidence that 'instability' can be evaluated with dynamic imaging studies*
- 'Instability' vs. 'dynamic compression'
  - Cfr cervical spondylomyelopathy
  - Compression is physiologically expected to worsen in extended position



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Dynamic imaging studies have questionable role in diagnosis of lumbosacral stenosis

Dynamic MRI is reliable for evaluation of the lumbosacral spine in healthy dogs

- MRI abnormalities occur in clinically normal dogs
- MRI abnormalities are 'physiologically' expected to worsen with extension

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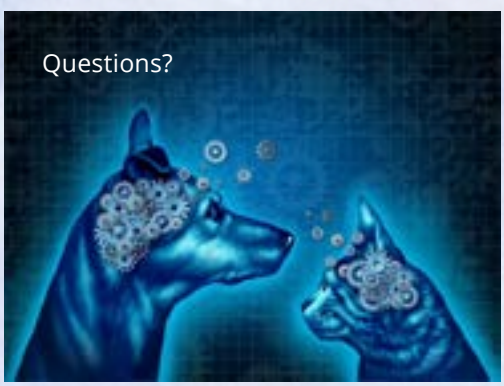

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CT and MRI in brain disorders part I

Royal Veterinary College
University of London

CT and MRI in brain disorders part I

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1

Introduction

- Wide variety of brain disorders described
- MRI is diagnostic modality of choice for most brain disorders
- MRI however not always able to differentiate between pathological processes
- MRI not always able to provide a final diagnosis

2

Tips for MRI interpretation – use a checklist!

- *For brain:*
  - Ü Intra-axial or extra-axial?
  - Ü Intensity of the lesion?
  - Ü Lesion sharply demarcated?
  - Ü Anatomical location of the lesion
  - Ü Perilesional edema present?
  - Ü Mass effect present:
    - Midline shift, brain herniation
  - Ü Contrast enhancement present?
    - None, peripheral or homogenous contrast uptake
  - Ü Surrounding tissues
    - Skull, middle ear, muscle

3

Intra-axial or extra-axial?

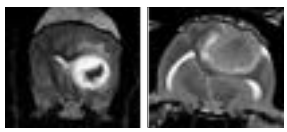
- Intra-axial = lesion originating from brain parenchyma
- Extra-axial = lesion NOT originating from brain parenchyma
  - Meninges, skull, blood vessels,….

How to differentiate between intra-axial and extra-axial lesions?

4

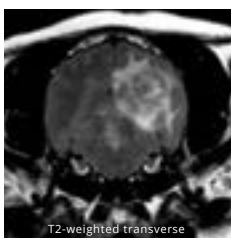
How to differentiate between extra-axial and intra-axial lesions?

- Location:
  - Intra-axial lesions typically within center of the brain, while extra-axial lesions often outside the brain
- Contrast-enhancement:
  - Extra-axial lesions not within blood brain barrier
  - Extra-axial lesions often characterized by uniform contrast enhancement



5

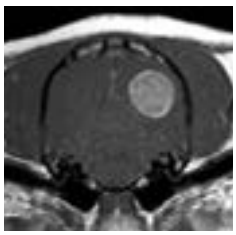
Intra-axial or extra-axial?



Central location suggests intra-axial lesion

6

Intra-axial or extra-axial?



- Uniform contrast enhancement suggests extra-axial lesion
  - Centrally located, uniformly contrast-enhancing mass lesion = metastatic brain neoplasia

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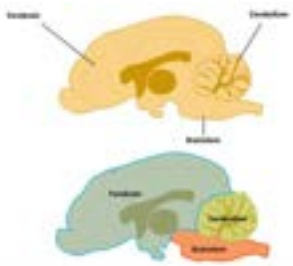
Anatomical location of the lesion



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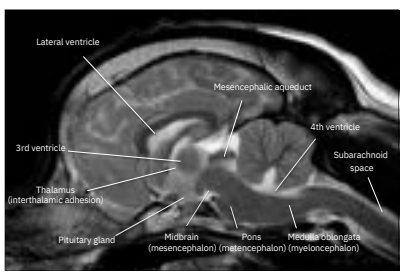
Anatomical location of the lesion



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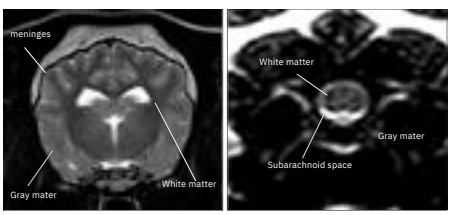
9

Anatomical location of the lesion

Meninges, gray matter and white matter



Gray matter is localized 'peripheral' in the brain and 'central' in the spinal cord

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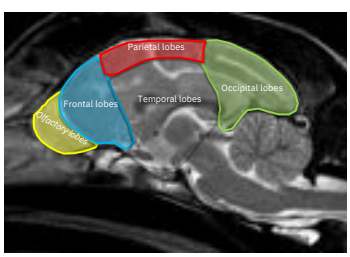
Anatomical location of the lesion



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Mass effect?

- Monro-Kellie doctrine:
  - Skull is a rigid, not expandable box with fixed volume:
  - Contains brain tissue, cerebrospinal fluid and blood
- Pathology can increase 'brain tissue' compartment, exhaust compensation mechanisms and cause increased intracranial pressure
- Diagnostic imaging findings suggestive for increased intracranial pressure is referred to as 'mass effect'

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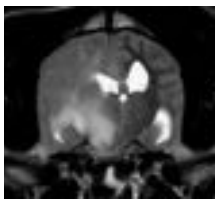
Mass effect?

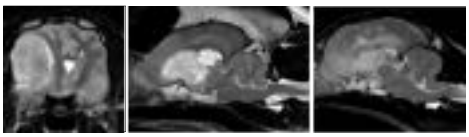
- Midline shift
- Ventricular compression
- Brain herniation:
  - (Caudal) transtentorial herniation
  - Subfalcine herniation
  - Foramen magnum herniation
- Effacement cerebral sulci
- Syringomyelia



Midline shift with lateral ventricle compression and effacement cerebral sulci

13

Increased intracranial pressure can result in brain herniation



Subfalcine herniation *Transtentorial herniation* *Foramen magnum herniation*

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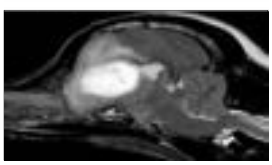
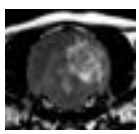
Syringomyelia can be indication of increased intracranial pressure



15

Edema?

- Different types of edema can be recognized:
  - Perilesional edema
  - Vasogenic edema
    - Disruption blood brain barrier
    - Edema follows path of least resistance
    - Edema most pronounced in white matter tracts
  - Cytotoxic edema
    - Energy failure with loss of function Na-K pump
    - Intraneuronal influx fluid
    - Swelling grey matter structures
  - Interstitial edema
    - Increased hydrostatic pressure
    - Failure ependymal lining
    - Leaking fluid out ventricular system or spinal canal



16

Case 1 - Robbie

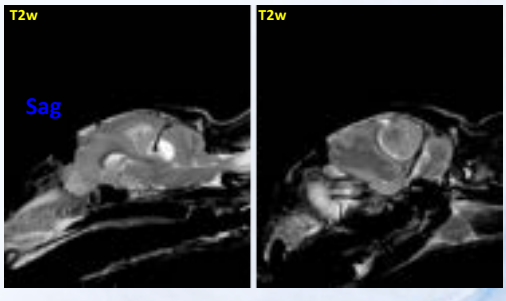
- 10 years old male neutered domestic shorthair
- Two-week history of progressive mentation change, compulsive circling to the left.
- Right sided absent menace response and absent proprioception right thoracic and right pelvic limb.

17

Case 1 - Robbie

Left- sided circling with right-sided neurological deficits suggestive for left-sided forebrain localisation

18



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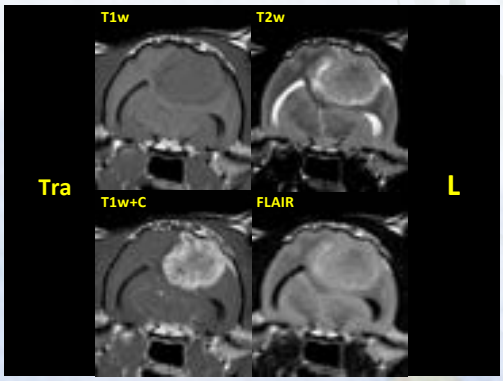

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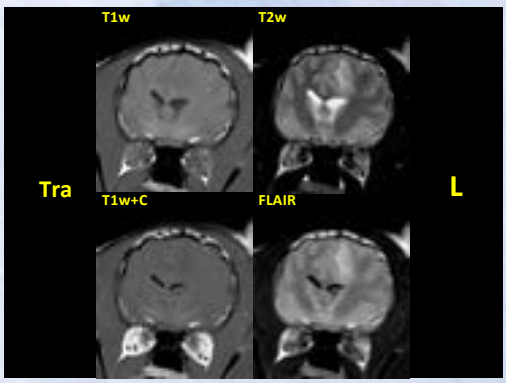

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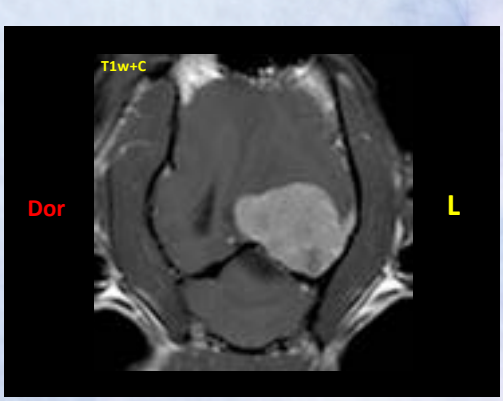

22

Case 1 - Robbie

- MRI interpretation:
- Well-demarcated, extra-axial, T2-weighted hyper to isointense, T1-weighted isointense, homogenously contrast-enhancing, mass in left occipital lobe
- The mass is associated with significant mass effect, perilesional and vasogenic edema
- Intracranial meningioma considered most likely
  - Surgery can be curative in cats
  - Surgery palliative in dogs

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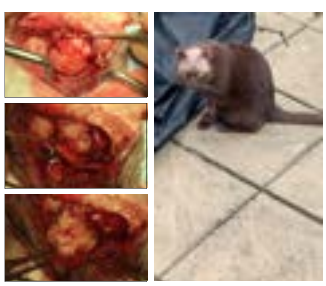
Surgical removal feline intracranial meningioma can be curative and associated with rapid recoveries



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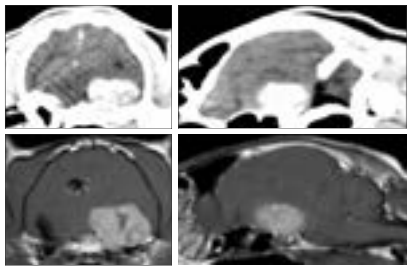
Intracranial meningioma also visible on CT



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Case 2 - Bono

- 9-years-old, male neutered Boxer
- Had an epileptic seizure yesterday and multiple other seizures since this morning.
- He is poorly responsive and disoriented

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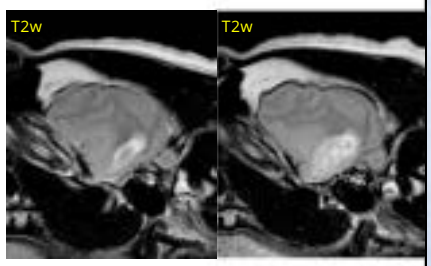

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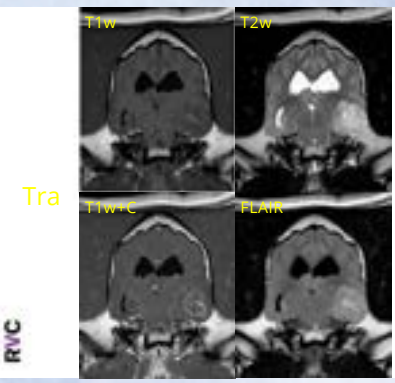

RVC

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Case 2 - Bono

- MRI interpretation:
  - Well demarcated, intra-axial, T2-weighted hyperintense and T1-weighted hypointense, lesion in left piriform lobe
  - Mild contrast enhancement, mild mass effect and moderate amount perilesional edema.
- Glioma considered most likely:
  - Astrocytoma
  - Oligodendroglioma

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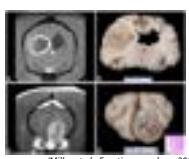
Brain tumours

- Primary vs secondary brain tumours
- Primary brain tumours:
  - Extra-axial vs. intra-axial tumours
  - Benign vs. malignant?
  - Meningioma
  - Pituitary neoplasia
  - Glioma:
    - Intra-axial, invasive, malignant brain tumour
    - Astrocytoma, Oligodendroglioma, Glioblastoma



(Miller et al., Frontiers oncology, 2019)

30

Diagnosis and treatment of glioma

- MRI is diagnostic modality of choice
- Treatment is challenging:
  - Surgery
  - Radiation
  - Immunotherapy

•Survival >12 months possible after surgery
•Long-term prognosis poor in dogs and humans

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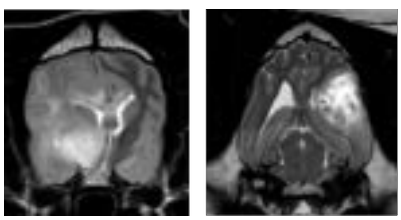
Can MRI reliably differentiate between astrocytoma and oligodendroglioma?

MAGNETIC RESONANCE IMAGING FEATURES OF INTRACRANIAL ASTROCYTOMAS AND OLIGODENDROGLIOMAS IN DOGS

32

Contact with meninges more suggestive for oligodendroglioma?



Astrocytoma Oligodendroglioma

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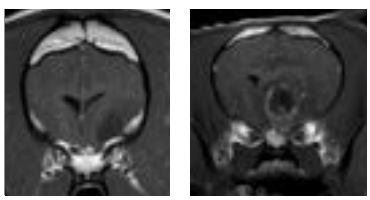
Contrast uptake indication for higher grade glioma



Low grade glioma High grade glioma

Higher grade associated with neovascularisation

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Case 3 – 'Dog'

- 6-years-old, Male neutered cross breed
- Experienced multiple collapsing episodes in the last month
- Has become less responsive and reluctant to move
- Neurological examination reveals cervical hyperaesthesia

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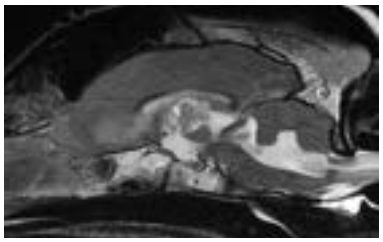
Case 3 – 'Dog'

•Extensive cervical and thoracic syringomyelia
- Dilatation 4th ventricle

36

Case 3 – 'Dog'



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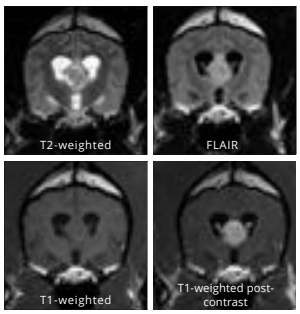
Case 3 – 'Dog'



38

Case 3 – 'Dog'

- MRI interpretation:
  - Well-demarcated, extra-axial, T2-weighted hyper -to isointense, FLAIR hyperintense, and T1-weighted isointense, mass associated with the 3rd ventricle
  - Minimal mass effect, uniform contrast enhancement, dilatation of the 4th ventricle and extensive syringomyelia
- Tumour of the ventricular system
- 4th ventricle dilatation and syringomyelia caused by overproduction cerebrospinal fluid *(functional neoplasia)*

39

Tumours associated with the ventricular system

- Choroid plexus papilloma
- Choroid plexus carcinoma
- Ependymoma (cats)
- 'drop metastases' and higher CSF protein suggestive for choroid plexus papilloma
- Symptomatic treatment with corticosteroids to reduce CSF production

40

MAGNETIC RESONANCE IMAGING FEATURES OF CANINE INTRACRANIAL NEOPLASIA

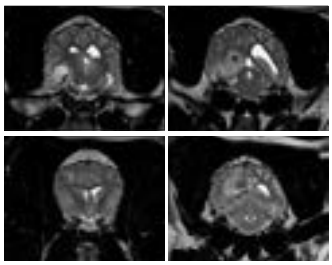
41

Case 4 - Margaux

- 9-years-old, female neutered Staffordshire bull terrier
- Had an epileptic seizure two weeks ago. Recovered well and was her normal self with 2 hours
- She has experienced multiple seizures in the last 3 days
- She is demonstrates now abnormal behaviour consisting of head pressing and compulsive pacing

42

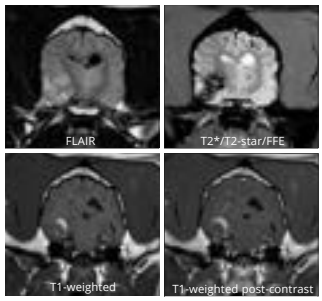
T2-weighted transverse MRI



Multiple intra-axial lesions with mixed intensity

43

Case 4 - Margaux



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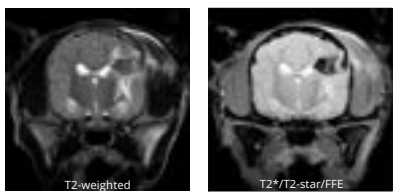
Case 4 - Margaux

- MRI interpretation:
  - Multiple, relative well-demarcated, intra-axial lesions of *mixed intensity* on T2 – and T1-weighted sequences
  - Mass effect present with perilesional and vasogenic edema and mild contrast enhancement
  - SIGNAL VOID ON T2*/T2-STAR/FFE

45

Intracranial hemorrhage can also be detected by MRI



- T2* GRE sequence especially useful for detecting hemorrhage
- Prone to susceptibility artefacts associated with magnetic field inhomegeneity
- Hemorrhage and hemosiderin associated with signal void
- Mineralization and gas also associated with signal void
- Terminology based on vendor MRI

46

Intracranial hemorrhage lesions can be associated with mixed intensity

Intensity on T2 and T1-weighted sequences dependent on age of hemorrhage and subsequent nature of iron breakdown products

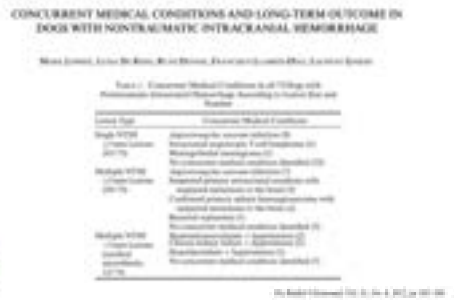
47

Differential diagnosis for intracranial hemorrhage in dogs

- Metastatic hemangiosarcoma!!
- Angiostrongylus vasorum infection
  - Lung worm
  - Common in UK
- Hemorrhage associated with intracranial neoplasia
  - Meningioma, glioma, lymphoma
- Systemic hypertension
- Trauma
  - Rare compared to humans

48

Size and number of lesions associated with possible underlying condition



CONCURRENT MEDICAL CONDITIONS AND LONG-TERM OUTCOME IN DOGS WITH NONTRAUMATIC INTRACRANIAL HEMORRHAGE

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Case 5 - Dillon

- 8 year old, Mn, Cross breed
- Normal this morning, when he suddenly developed difficulties walking
- Does not seem to be painful
- Clinical signs have not progressed or improved

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Case 5 - Dillon

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Case 5 - Dillon

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Case 5 - Dillon

- Ataxia LTL and LPL
- No paresis present!!
- Hypermetria LTL and LPL
  - Hypermetria characterised by overflexion joints
- Normal mentation, no cranial nerve deficits, no proprioceptive deficits, intact spinal reflexes, and no pain on spinal palpation

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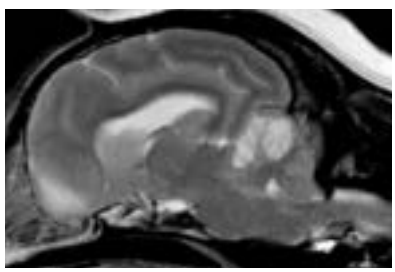
Case 5 - Dillon



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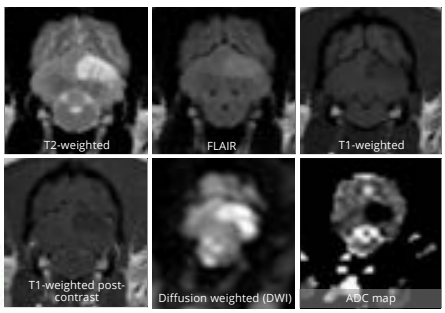
Case 5 - Dillon



55

Case 5 - Dillon

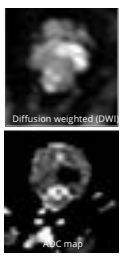
- MRI interpretation:
  - Sharply demarcated, homogenously T2-weighted hyperintense and T1-weighted hypointense, intra-axial lesion in rostral cerebellar hemisphere
  - No mass effect, no contrast enhancement and lesion limited to grey matter
  - Value diffusion weighted imaging?

Ischemic infarct rostral cerebellar artery

56

Diffusion weighted imaging and ADC map?

- Diffusion weighted imaging
  - Evaluates water transport
  - Ischemic stroke associated with increased intraneural water content and reduced diffusion
  - Does not exclusively evaluate diffusion
- ADC = Apparent diffusion coefficient
  - Exclusively evaluates diffusion
- Ischemic infarct
  - Hyperintensity on Diffusion weighted
  - Reduced ADC



57

Diffusion weighted imaging and ADC map?

- Provides complementary information
  - Improves sensitivity and specificity for diagnosis of ischemic stroke
- Not useful for spinal MRI

58

Cerebrovascular accidents – Ischaemic infarct

- Cerebrovascular accidents or 'strokes' increasingly recognized in animals
- Clinical presentation characterised by *peracute* onset of *non-progressive* and *focal* (often obviously lateralised) clinical signs
- If not immediately fatal, very *good prognosis* with improvement expected in couple of days

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Dillon two weeks later

60

MRI characteristics ischemic infarct

- Sharply demarcated, homogenous hyperintense on T2-weighted and hypointense on T1-weighted weighted images
- T2-weighted hyperintensity reflects cytotoxic edema
  - 'Swollen neurons'
  - Vasogenic edema can be seen in subacute stage
- No contrast uptake and no mass effect
  - Mild peripheral contrast uptake possible in chronic stages
  - Cytotoxic (and eventual vasogenic) edema can cause mild mass effect
- Affects grey matter and anatomically associated with area of vascular territory
  - Affects preferential anatomical areas
- Varying in size
  - Territorial vs. lacunar infarct

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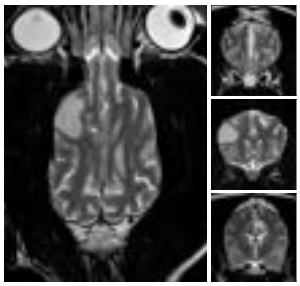
Ischemic infarct associated with grey matter



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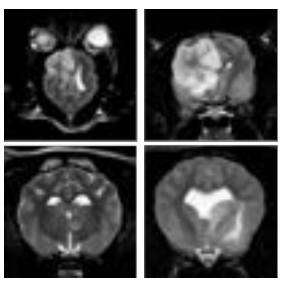
Ischemic infarct associated with specific anatomical structures and varying in size



Territorial infarct:
- Infarction major artery
- 'Large infarct'

Lacunar infarct:
- Infarction deeper, small artery
- 'Small infarct'

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Can ischemic infarct be diagnosed by CT?

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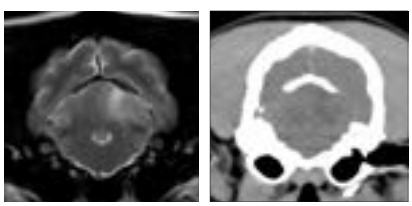
Increased fluid content (cytotoxic edema) associated with sharply demarcated hypodense area



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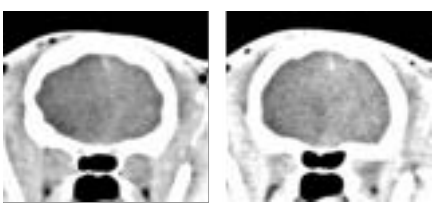
Ischemic infract characterized by sharply delineated hypodense/hypoattenuating area on CT



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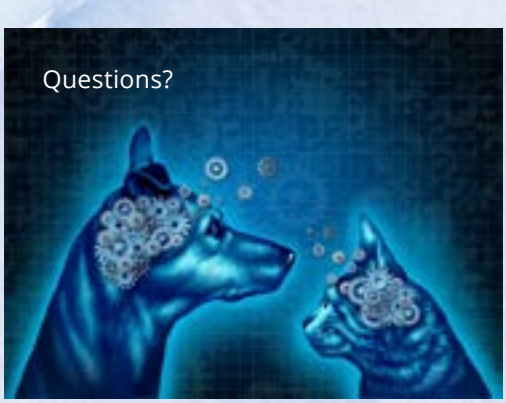
Questions?

CT and MRI in brain disorders part II

Royal Veterinary College
University of London

CT and MRI in brain disorders part II

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1

Case 1 - Winny

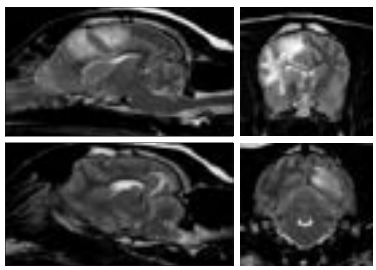
- 3-year-old female neutered Pekingese
- Developed an abnormal head position 1 week ago
- Started to demonstrate abnormal behaviour and became less responsive
- This morning she collapsed and had a generalized tonic-clonic seizure

2

Case 1 - Winny

3

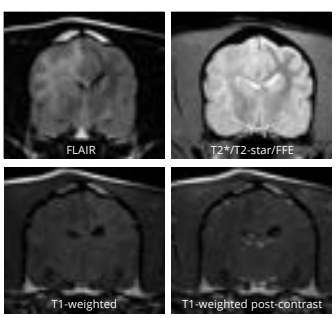
T2-weighted images Winny



Multiple poorly demarcated, bilateral intra-axial lesions

4

Case 1 - Winny



5

Case 1 - Winny

- MRI interpretation:
  - Multiple, bilateral, intra-axial, T2-weighted hyperintense and T1-weighted hypointense, poorly demarcated lesions
  - Mass effect and extensive vasogenic edema present
  - Minimal contrast enhancement present
- Multiple, poorly demarcated lesions suggestive for inflammatory disease
- Meningoencephalitis of unknown origin = most common inflammatory condition of the central nervous system

6

Inflammatory central nervous system (CNS) disorders can be infectious or non-infectious

Infectious

- Bacterial
- Viral (Canine Distemper,..)
- Parasitic (Toxoplasma, Neospora,...)
- Fungal

Non-infectious

- Steroid responsive meningitis arteritis
- Eosinophilic meningitis
- Idiopathic tremor syndrome
- Idiopathic hypertrophic pachymeningitis
- Meningoencephalitis of unknown aetiology/origin

In most countries, Non-infectious causes of CNS inflammation much more common

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Non-infectious causes of CNS inflammation are more common than infectious causes

Frontiers in Veterinary Science

Inflammatory Disease Affecting the Central Nervous System in Dogs: A Retrospective Study in England (2010–2019)

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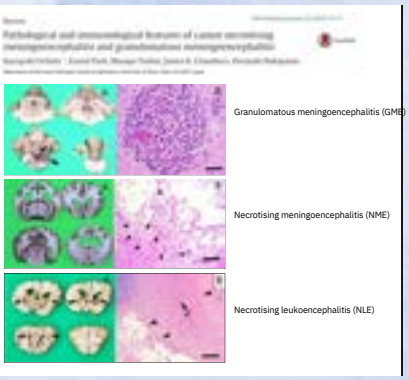

Granulomatous meningoencephalitis (GME)

Necrotising meningoencephalitis (NME)

Necrotising leukoencephalitis (NLE)

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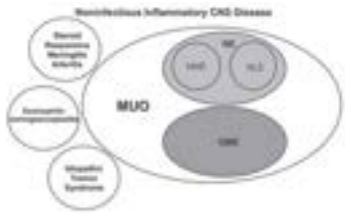
Making a definitive diagnosis of GME, NME or NLE is often not possible in a clinical setting....



MUA or MUO = cases in which clinical findings suggest a non-infectious aetiology for meningoencephalitis but a definitive histopathological diagnosis is lacking

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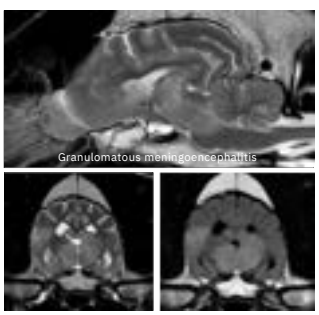
Diagnosis of MUA based on MRI and CSF analysis



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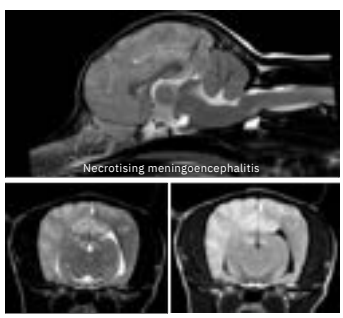
Diagnosis of MUA based on MRI and CSF analysis



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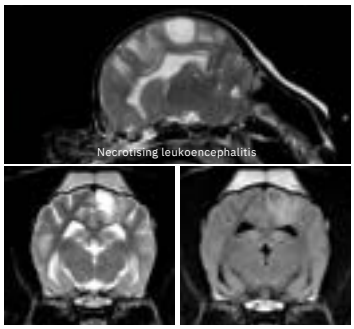
Diagnosis of MUA based on MRI and CSF analysis



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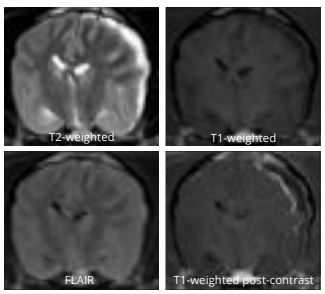
Meningoencephalitis of unknown origin

- Treatment based on immunosuppressive drugs
- Corticosteroids
- Corticosteroid + adjunctive immunomodulating drug
  - Cytosine arabinoside, cyclosporine,...
- Variable response to treatment
  - Up to 26% dies within first week despite aggressive treatment

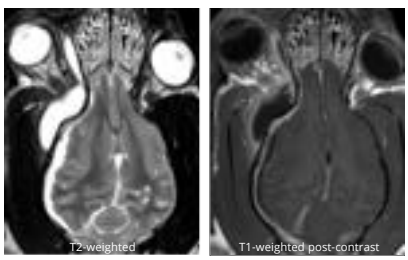
14

Intracranial empyema is most common cause of infectious CNS inflammation in dogs



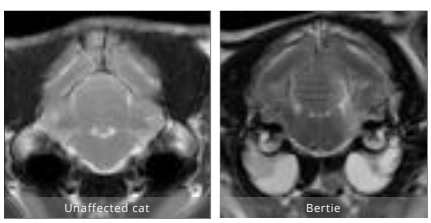
15

Intracranial empyema is most common cause of infectious CNS inflammation in dogs



16

Extension otitis media interna is common cause of intracranial empyema



- Bilateral otitis media with intracranial extension
- Intracranial empyema

17

Feline infectious peritonitis virus (FIP) is most common cause of CNS inflammation in cats

- FIP virus predominantly affects meninges, choroid plexus and ependyma
- Common MRI findings include:
  - Meningeal contrast enhancement
  - Ependymal contrast enhancement
  - Ventriculomegaly/hydrocephalus
  - Syringomyelia

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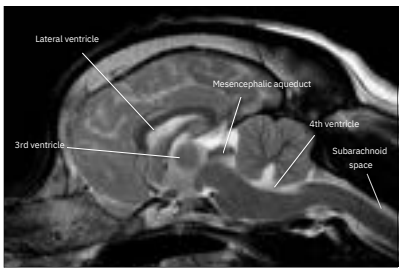
Meninges and ependymal lining preferentially affected in cats with FIP virus



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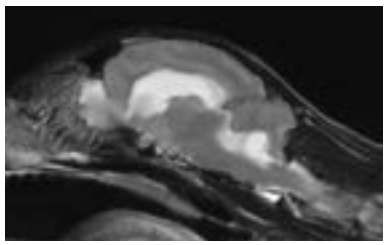
FIP common cause of hydrocephalus in cats



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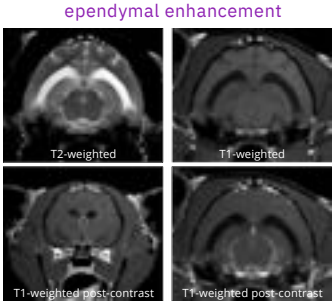
FIP commonly associated with ventriculomegaly, meningeal enhancement and ependymal enhancement



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Journal of Veterinary Internal Medicine

ACVIM

Standard Article

Clinicopathologic Features and Magnetic Resonance Imaging Findings in 24 Cats With Histopathologically Confirmed Neurologic Feline Infectious Peritonitis

22

Case 2 - Sasha

- 14 week old, Female, Pekingese
- 'Not normal' since birth
- Problem has become progressively wor se
- Has a tendency to walk in circles and less responsive compared to litter mates

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Case 2 - Sasha

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Case 2 - Sasha

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Case 2 - Sasha

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Neuro exam:

1. Mentation/behaviour: walking in circles to the left. Less responsive?
2. Gait/posture: Intermittent falling to either side. No obvious ataxia or paresis. Dome shaped head?
3. Proprioception: intact
4. Cranial nerves: absent menace response both eyes. Bilateral 'spontaneous' ventrolateral strabismus
5. Spinal reflexes: unremarkable
6. Spinal palpation: mild to cervical hyperaesthesia

Neuro-anatomical localisation: forebrain

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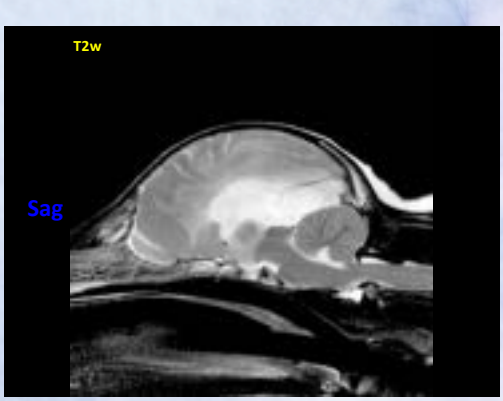

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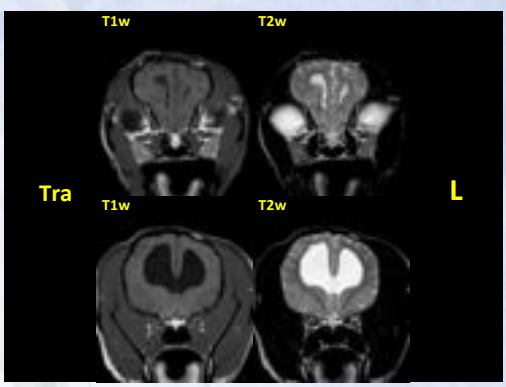

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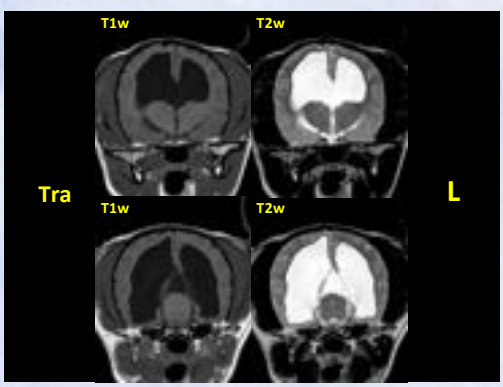

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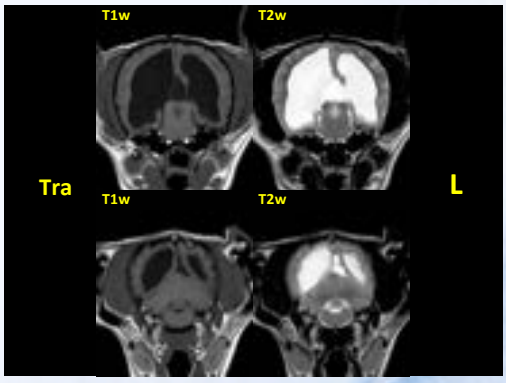

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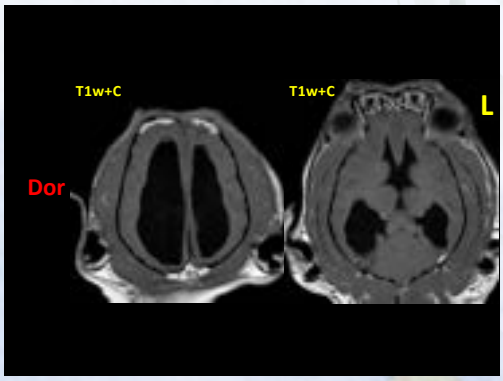

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Case 2 - Sasha

- MRI interpretation:
  - Ventriculomegaly with severe dilation lateral and third ventricles
  - Fourth ventricle not dilated
  - Obstructive hydrocephalus

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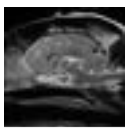
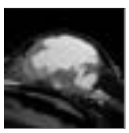
Hydrocephalus

- Abnormal dilation of the ventricular system
- Excessive accumulation cerebrospinal fluid
- Congenital vs. acquired
- Young toy breed dogs:
  - Chihuahua
  - Pomeranian
  - English bulldog
  - Pug
  - Lhasa Apso
- Clinical signs caused by destruction neurons and increased intracranial pressure
- Clinical signs variable and not always suggestive for forebrain disease
- Abnormal skull development can be seen





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Abnormal skull development can be seen

Dome-shaped head

- 'Resting' ventrolateral strabismus caused by distortion of the orbits?
  - 'Setting sun sign'

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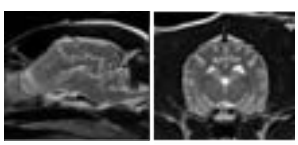
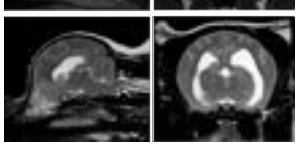
Obtaining a diagnosis complicated by 'breed specific' variations in ventricle size - ventriculomegaly



Labrador retriever with idiopathic epilepsy



Cavalier King Charles Spaniel with syringomyelia

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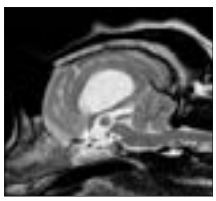
Ventriculomegaly or hydrocephalus?



MAGNETIC RESONANCE IMAGING FINDINGS ASSOCIATED WITH LATERAL CEREBRAL VENTRICULOMEGALY IN ENGLISH BULLDOGS

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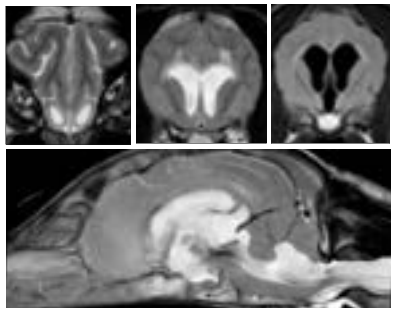
Ventriculomegaly or hydrocephalus?



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Magnetic resonance imaging signs of high intraventricular pressure - comparison of findings in dogs with clinically relevant internal hydrocephalus and asymptomatic dogs with ventriculomegaly

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Can MRI reliably differentiate between neoplastic, inflammatory and vascular disorders?

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Diagnostic accuracy MRI

- MRI is diagnostic modality of choice for most brain and spinal conditions
- MRI is not the 'golden bullet'
  - Overlap between imaging characteristics of pathological processes
  - Definitive diagnosis only achieved by histopathology
- Even specialists can have difficulties making a 'most likely' diagnosis on MRI
- Incorporation clinical factors
  - MRI does not replace need for good clinical history general physical and neurological examination

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Magnetic Resonance Imaging for the Differentiation of Neoplastic, Inflammatory, and Cerebrovascular Brain Disease in Dogs

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RVC

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Evaluation of magnetic resonance imaging for the differentiation of inflammatory, neoplastic, and vascular intradural spinal cord diseases in the dog

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[redacted]

MRI does not replace need for good clinical history and clinical examination

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Case 3 - Benny

- 4-year old Border Collie
- Had an epileptic seizure two weeks ago
- Had another seizure yesterday
- Had multiple (> 10) seizures today

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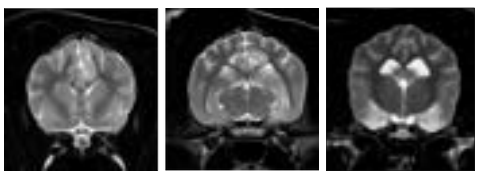
Transverse T2-weighted images - Benny



Multiple poorly demarcated hyperintensities affecting the cingulate gyrus, hippocampus and piriform lobes

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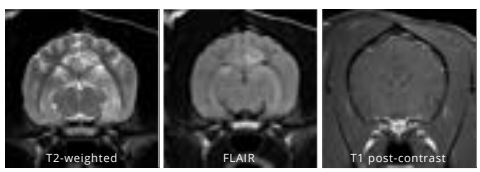
Case 3 - Benny



Lesions also hyperintense on FLAIR. No contrast enhancement

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Case 3 - Benny

- *MRI interpretation:*
  - Multiple, poorly demarcated intra-axial, T2-weighted/FLAIR hyperintense lesions affecting cingulate gyrus, hippocampus, piriform lobes
  - No contrast enhancement and minimal to no mass effect

'Post-ictal edema'

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REVERSIBLE MAGNETIC RESONANCE IMAGING ABNORMALITIES IN DOGS FOLLOWING SEIZURES

[redacted]

[redacted]

MRI abnormalities can be cause or consequence of epileptic seizures

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JAVMA

AVMA

Prevalence, distribution, and clinical associations of suspected postictal changes on brain magnetic resonance imaging in epileptic dogs

RVC

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Case 4 - Tank

- 5-yr-old Mn English Staffordshire bull terrier
- Chronic, progressive behavior change of 6 months duration

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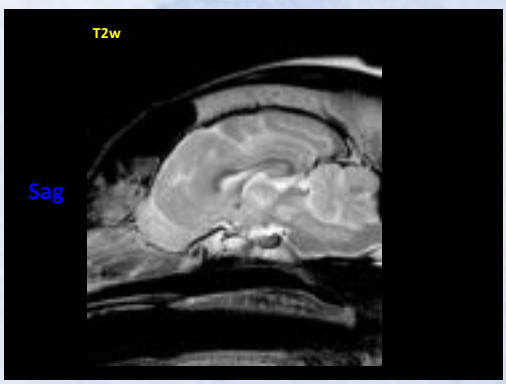

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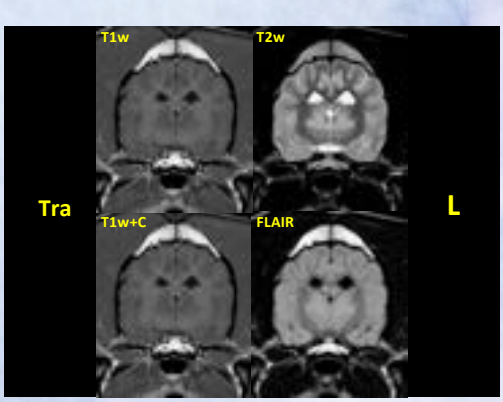

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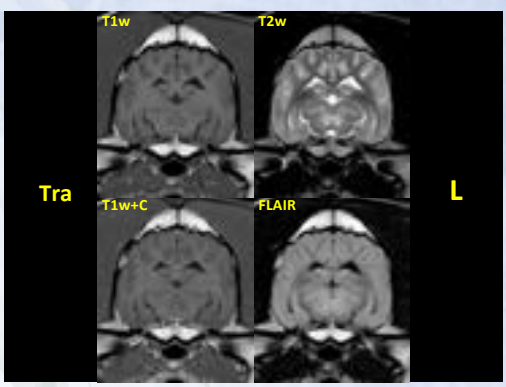

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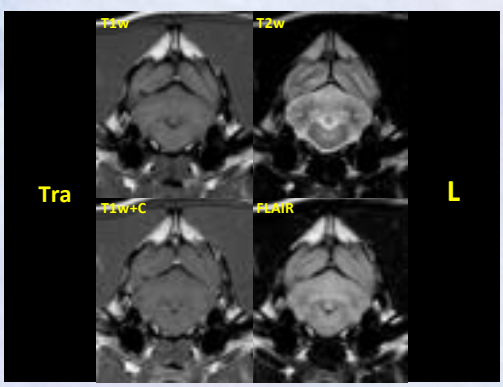

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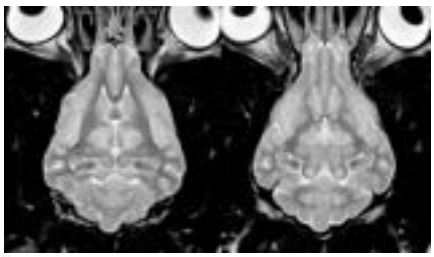

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Case 4 - Tank

MRI interpretation:

- Multiple well-demarcated, intra-axial lesions in thalamus, brainstem and cerebellum
- No contrast enhancement and no mass effect

- **BILATERAL AND SYMMETRIC LESIONS**

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Bilateral and symmetrical MRI lesions

Suggestive for:

- **Toxic disorder**
- **Metabolic disorder**
- **Neurodegenerative disorder**

- L2-hydroxy-glutaric-aciduria = hereditary metabolic disorder in English Staffordshire bull terriers

- Genetic test available

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Thiamine (Vitamin B1) deficiency

- Nutritional disorder
  - All-fish or poorly balanced diet
  - Anorexic cats
  - Gastro-intestinal disease

- Bilateral or unilateral vestibular syndrome

- Bilateral mydriasis, cervical ventroflexion, decreased mentation, vocalization, opisthotonus, epileptic seizures, tight curled up position

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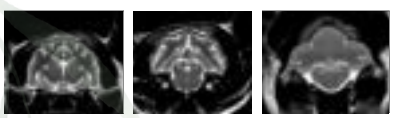
Thiamine deficiency

- Diagnosis based on compatible clinical history and compatible clinical signs

- Measurement of thiamine in blood

- Magnetic resonance imaging
  - Bilateral symmetrical hyperintense lesions in midbrain and brainstem nuclei *(including vestibular nuclei*



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Thiamine deficiency

- Treatment:
  - Thiamine supplementation:
  - 12.5 – 25 mg total dose/cat IM or SC
  - Followed up by oral supplememntation until resolution clinical signs

- Prognosis good if early treatment is initiated

- Can be fatal if left untreated

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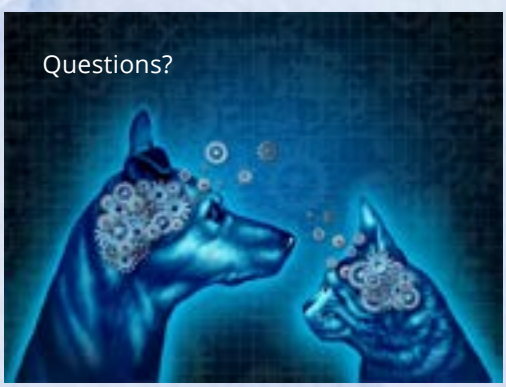
Questions?

Immune mediated Thrombocytopenia (ITP) and Hemolytic Anemia (IMHA)- Management in General practice

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- Immune thrombocytopenia is a diagnosis of exclusion and In human medicine - defined as platelet counts below 100,000 platelets per microliter with no clear underlying cause.
- Secondary ITP induced by discordes like autoimmune disorders, lymphoproliferative disorders, infectious agents, transfusion, or drugs
- **Decreased production :** BM Neoplasia, Infection, Endotoxemia, Fungal-systemic, Rickettesial, Viral CD, Parvo, Drugs : Estrogens, Thiazides, Albendazole, grisofulvin
- **Immune mediated destruction :** Primary- Evans syndrome, Secondary - Infections- babesios, E canis,lepto, Autoimmune disorders, lymphoproliferative disorders, transfusion, or drugs
- **Increased utilization/destruction:** DIC,Septecemia,Uremia, Vasculitis
- **Sequestration** : Hepatomegaly, Sepsis, spleen diseases (neoplasms, inflammatory or torsion)
- IMT accounts for approximately 5-15% of canine thrombocytopenia cases. In a study of 871 dogs with thrombocytopenia, IMT accounted for only 49 cases (5.6%).
- Platelets are small round anucleate cells - produced by megakaryocytes (MKs) in the bone marrow and these are polynuclear cells that protrude extensions in the blood (proplatelets) and eventually bud off platelets - then circulate for approximately 7–10 days undergoing age related changes.
- When platelets age - become desialylated - recognized and cleared by the hepatic Ashwell-Morell receptor.
- Thrombopoietin (TPO) is the key hormone responsible for platelet production. It is primarily synthesized in the liver and promotes MKs to produce platelets in the bone marrow
- TPO cleared by binding to its receptor, the myeloproliferative leukemia protein (Mpl) receptor, on platelets and megakaryocytes. As more platelets are cleared, more TPO is produced.
- IMTP is an example of a type II hypersensitivity - antibodies are formed against a platelet antigen. The attachment of antibody to the platelet - destruction by the mononuclear phagocytic cell system, or complement-mediated destruction

- It is believed that autoantibodies and autoreactive CD8+ cytotoxic T cells (Tc) trigger enhanced platelet destruction and impair platelet Productions by megakaryocytes in IMT. T cells also contribute to platelet destruction, with predominantly from Th1 and Th17 cells.
- Platelet autoantibodies (IgG) bind to the platelet surface, mediated by macrophage Fc receptor binding of antibody-coated platelets.Platelet-associated IgG levels are increased in most patients. Most primary IMT patients have antibodies directed against platelet membrane glycoproteins (required for platelet functions), such as GP IIb/IIIa and GP Ib-IX
- Few studies diocumented tthat Megakaryocytes can present antigens on their surface in association with MHC Class I molecules, activating specific CD8+ T cells. – may trasnfer foreign antigen to pro platelets.
- Abnormal platelets are cleared through phagocytosis by splenic macrophages or dendritic cells and by induction of apoptosis- reducing life span in patients with IMT <1 day. Thrombocytopenia develops when platelet destruction exceeds compensatory platelet production by marrow megakaryocytes.
- Platelet dysfunction : NSAIDs and VWD are the most common. Other causes are Paraproteinemia (multiple myeloma, ehrlichiosis, lymphocytic leukemia), liver disease, uremia, platelet coating by fibrin degradation products in DIC, and dextran, phenothiazine tranquiller and other drugs
- Thromboembolism: caused by protein losing nephropathy (nephrotic syndrome), protein losing enteropathy, neoplasia, necrotizing pancreatitis, autoimmune hemolytic anemia, hyperadrenocorticism, cardiac disease, sepsis, trauma, atherosclerosis and major surgical procedures.
- In Human medicine, the genetic factors and environmental factors do contribute to development of ITP. There are no such reports avialable in veterinary medicine, ocker spaniel, miniature poodle, toy poodle, and old English sheepdog are overrepresented.

Thrombocytopenia Main differentials

- Anemia and leukopenia—Neoplastic infiltration, and immune-mediated, chemically induced, or infectious causes e.g., ehrlichiosis
- Anemia with spherocytosis with or without agglutination—consider immune-mediated hemolytic anemia with secondary immune-mediated thrombocytopenia
- Anemia, leukopenia or leukocytosis, and proteinuria—consider SLE
- Eosinophilia—consider heartworm disease
- Morulae detected in Monocytes—consider E. canis
- In a study of 61 thrombocytopenic dogs, 57% - primary ITP, 28% secondary ITP - lymphoid/myeloid neoplasia (9.8%), infectious disease (9.8%), liver disease (5%), or drug exposure (3%), and 15% had non-immune thrombocytopenia - bone marrow aplasia or consumptive coagulopathy. (Makielski et al . J Vet Intern Med. 2018;32(3):1041-1050)
- Another recente study – neoplasia (27.3%), miscellaneous causes (26.9%), primary ITP (18.8%), inflammatory/immune-mediated disorders (14.4%) and infectious diseases (12.6%). Dogs with primary ITP had significantly lower platelet concentrations (median 8 × 109 /L, range: 0-70 × 109 /L) than dogs in the other four categories. Platelet concentration was useful for distinguishing Primary ITP from other causes of thrombocytopenia (with concentration of ≤12 × 109 /L being 60% sensitive and 90% specific, Francés et al (2023)Vet Med Sci. July ;9(4):1495-1507)
- **The risk of spontaneous bleeding theoretically occurs with platelet counts less than 30 000/µL However, not all dogs show bleeding tendency at this count or even at lower count**. American Society of Hematology (ASH) recommends to treat when count is less than 30 K or bleeding signs
- Petechiae and ecchymosis, epistaxis or haematuria are often most visible signs followed by GIT bleeding. Mucosal bleeding or bleeding in body cavities, Hyphema can be common few dogs, Pulmonary bleeding uncommon but must be suspected when presented as unexplained cough, tachypnoea or dyspnoea.

- **Diagnosis**

1. Rule out common diseases - History, examination, CBC , blood chemistry panel and urinalysis for systemic diseases
2. PCR for vector-borne disease screening - Anaplasma phagocytophilum, Ehrlichia canis, Babesia gibsoni, and Leishmania infantum . B canis may be presented only with Thrombocytopenia
3. Imaging to rule out neoplasia.
4. Platelets count- which analyzer ? Avoid Human ? Severe (<20 000 platelets/ µL) thrombocytopenia is suggestive of primary ITP. In one study of 30 dogs with IMT, 77% had a platelet count <30,000/µWhile in an other study another study of 46 dogs with primary IMT reported that 76% had thrombocytopenia <10,000/µL
5. Manual examination of a blood smear should always be performed when Spurious thrombocytopenia (pseudothrombocytopenia) is noticed - presence of clots in the collection tube, platelet clumping or the failure of automated analysers to count macrothrombocytes,
6. Finding 10-15 platelets per high powered (oil immersion) field indicates normal platelet number with each platelet seen representing 15,000 circulating platelets.
7. Increased MPV supports an ITP diagnosis, but a normal to low MPV does not exclude the diagnosis. Use of immature platelet fractions/reticulated platelets as an ITP diagnostic tool not reliable. immature platelet fraction (IPF) may help to differentiate reduced production vs increased destruction. The assay for these are not easily available for general practice.
8. Assay of autoantibodies – Only one study identified anti-GPIIb and IIIa antibodies in the serum (24%)of affected dogs. Useful for knowing mechanism and may be help in guiding therapy
9. The traditional method of measuring serum antiplatelet antibody is the platelet factor-3 (PF-3) immunoinjury technique. No current test for antiplatelet antibody has indisputable diagnostic accuracy and clinical utility.
10. B cell activating factor (BAFF) is a cytokine involved in B cell maturation and survival. was increased substantially in dogs with primary IMT and may help to know thrombocytopenia is primary immune-mediated disease or other factors.
11. Assays to measure canine TPO- Not available at the moment but usefulness not established
12. The DOGiBAT scoring system assigns bleeding severity grades at nine anatomic sites has been developed similar to human ITP-specific Bleeding Assessment Tool (TP-BAT) - numeric scores based on the severity of hemorrhage- Not validated but may be useful for prognosis and response to treatment
13. Thromboelastometry - measure of clot firmness and Flow cytometry for platelet function – not readily available for general practice
14. BM examination- Not routinely done Benefits remains unclear for ITP diagnosis and therapy- if megathrombocyte or reticulated platelet numbers are low , or non reg anemia

15. DIC : the causes of consumptive thrombocytopenia are disseminated intravascular coagulation (DIC), and vasculitis. - suspected in a thrombocytopenic patient that has prolonged PT and PTT, increases in d-dimers or fibrin degradation products (FDPs), Consider underying causes like systemic inflammatory disease (infectious / non-infectious), neoplastic diseases, trauma, heat stroke, and severe hepatic disease. In patients with IMT, PT and PTT should be normal, and d dimers or FDPs should be normal or be present in low concentrations

- **Treat the underlying cause**

Management of Thrombocytopenia

- Treat underlying infectious or neoplastic disease if present. For example, Doxycline 10 mg/kg q12h for 28 days for E canis
- No specific protocol or guidelines are avialable for management of IMT
- Treatment goal is to keep Platelet count >100K with no evidence of bleeding. If count is less than 30K or ongoing bleeding considered as No response. If platelet count >30K but less than 100K with 2 times increase in count from diagnosis with absence of bleeding is considered as partial response. Complete response is one where count is more than 100K without bleeding and No further treatment.
- The IMT should have been well controlled (with the platelet count in or above the normal range) for at least two weeks before tapering immunosuppressive doses. The dose should not be reduced by more than 25 to 33 per cent in one go during the first few weeks. Dose reductions should not be made more frequently than once every two weeks
- For immune-mediated thrombocytopenia: prednisone 1 mg/kg PO q12h in conjunction with or without azathioprine 1-2 mg/kg PO q24h for 14 days, then every other day. Prednisone is typically given at this initial daily dose for at least 2-3 weeks; reduce dose every 2-3 weeks by 20% until acceptable platelet count is achieved.
- Prednisolone along with either human IVIG or Vincristine in few studies documented shorten recovery time with safe platelets count in severe /acute cases of IMT ((Rozanski and others 2002, Bianco and others 2009, Balog and others 2013).
- Cyclosporine, or leflunomide or Mycophenolate mofetil can be used if patients can't tolerate other drugs, or owners can't tolerate side effects in their pets. In a study Mycophenolate alone rapid and durable remission at 8.5 mg per kg Q 12 hours ((Yau and Bianco 2014).
- **Combination of Mycophenolate Mofetil and corticosteroids was as effective as cyclosporine and corticosteroids** in the treatment of presumed primary IMT in dogs (Cummings (2017) JSAP 58, 96–102)

- Dogs with IMHA- prednisolone or prednisone at an initial PO dosage of 2-3 mg/kg/day, or 50-60 mg/m2/day for dogs >25 kg, The drug may be administered as a single daily dose or divided into 2 daily doses.
- If anemia is not improved after 7 days or stabilized or requires repeated blood transfusion- second drug may be added as follows
- Azathioprine: 2 mg/kg or 50 mg/m2 PO q24h. After 2-3 weeks, the dosing interval may be increased to every other day until treatment is discontinued.
- Cyclosporine: 5 mg/kg PO q12h. **Mycophenolate mofetil: 8-12 mg/kg PO q12h**
- Leflunomide: 2 mg/kg PO q24h.
- Danazol 5 mg/kg q12h; IV IgG 0.5 g/kg over 6 h if refractory. Gradually taper immunosuppressive therapy once platelet count reaches 200,000 cells/uL.(Some suggest > 40,000/ul)
- **Vincristine** – Vinca alkaloid, Binds to Alpha/beta tubulin dimers – preventing microtubule formation. Cytolytic vs megakaryocytes- release platelets. Reduces Platelket phagocytosis. Decrease autoantibody synthesis and autoantibody binding. 0.5 mg/m2 IV if platelet count <10 20,000 cells/uL or bleeding; consider bone marrow aspiration to document presence of megakaryocytes. In a study using vincristine 0.02 mg per kg vs human IVIG 0.5G/kg in 20 dogs, no significant differences noticed in outcome.
- Transfuse fresh whole blood or platelet rich plasma 10-20 ml/kg over 2-4 hr to stop active bleeding. Platelet transfusion products – Platelet rich plasma, concentrate, cryopreserved platelets and lyophilized platelets
- At 1 hour post whole blood transfusion the anticipated platelet rise per transfusion is only modest (20,000/ul per 10ml fresh whole blood/kg transfusion).
- Platelet can only be transfused from freshly collected blood kept for <12 hours at room temperature, In ITP transfused platelets are thought to have an extremely short survival of minutes to hours rather than normal 7-10 days.
- Administration of IV immunoglobulin (IVIG) at a dosage of 0.5-1 g/kg as a single infusion may be considered as a salvage measure in dogs not responding to treatment with 2 immunosuppressive drugs of IMHA (or IMT ??) action is likely associated with blocking Fc-mediated phagocytosis.
- Splenectomy may be considered in refractory or relapsing cases of ITP, but no data is available in dogs.
- Romiplostim (a human thrombopoietin receptor agonist -Romy by Intas)- TPO receptor agonist that is used for IMT in people. Four dogs were administered 3–5 μg/kg SC weight once weekly. - associated with an increase in platelet counts in all five dogs. Four of the five dogs entered remission and relapses were not observed over a follow-up period of 3–10 months.(KOHN, et al 2016, BMC Veterinary Research 12, 96).

- In another case report of refractory IMT, , romiplostim 15 µg/kg, SC , 1 week apart, resulted in complete clinical and hematological remission and remained as such post 38 months (Polydoros et al (2021)Top Companion Anim Med. March 42(0):100488)
- The median time for platelet recovery (>50 000/µL) after romiplostim administration was 4 days, and the median time for platelet count normalization was 7 days. The survival-to-discharge rates were 85%, 40%, and 28.6% for dogs with primary ITP, secondary thrombocytopenia (pancytopenia of unknown etiology, chemotherapy-induced thrombocytopenia, babesiosis, radiotherapy induced thrombocytopenia and disseminated intravascular coagulopathy), and thrombocytopenia of unknown etiology, respectively. (Min-Ok Ryu et al (2024) J Vet Intern Med. Jul-Aug;38(4):2158 – 2164)
- Eltrombopag, another TPO receptor agonist commonly used in people, is ineffective in the dog as it cannot bind to the canine TPO receptor
- Other investigative drugs- therapeutic plasmapheresis, liposomal clodronate, hyperbaric oxygen therapy, and melatonin,
- Carica Papaya extract 350mgand Tinospora cordifolia extract 150mg drug dose ?? Not validated or no controlled studies in dogs

- **Prognosis**
  - The presence of concurrent IMT and IMHA is generally associated with a worse prognosis than is IMT alone.
  - Retrospective studies consistently show that more than 80 per cent of dogs survive to hospital discharge (Callan and Catalfamo 2017).
  - In a study involving 45 dogs with primary immune-mediated thrombocytopenia. 89·6% of patients survived to discharge and 31% of those experienced a relapse following discharge.
  - The median time from diagnosis to relapse was 79 days. Of dogs that experienced a relapse, 50% had at least one further relapse (Simpson et al (2018) JSAP 59, 674–680)
  - The prognosis for canine IMT without pulmonary or CNS bleeding was good in a study.
  - Other studies - dogs with elevated BUN on admission and melena were less likely to survive to discharge compared with dogs with normal BUN and without melena.
- **New therapies**
  - Monoclonal antibodies that produce selective depletion of the B cell compartment to decrease autoantibody production
  - Administration of peptide antigens by subcutaneous or sublingual routes to establish tolerance
  - Adoptive transfer of regulatory T cells (Tregs)
  - Administration of low dose recombinant interleukin 2 to encourage proliferation and activation of Tregs

Further reading

- LeVine DN, Brooks MB. Immune thrombocytopenia (ITP): Pathophysiology update and diagnostic dilemmas. Vet Clin Pathol. 2019;48(Suppl. 1):17– 28. https ://doi.org/10.1111/vcp.12774
- Li J, Sullivan JA, Ni H. Pathophysiology of immune thrombocytopenia. Curr Opin Hematol. 2018;25(5):373-381
- O'Marra SK, et al. Treatment and predictors of outcome in dogs with immune-mediated thrombocytopenia. J Am Vet Med Assoc 2011;238:346–352.

IMHA

- Primary disease is the most common form in dogs and secondary common in cats
- Any , breed or sex but Typically seen in young middle-aged dogs (median age 6 years)- Cocker and Springer Spaniels, Poodles and Collies.
- Strong association between several DLA-79 gene mutations and immune-mediated diseases, including IMHA, has been demonstrated in dogs
- Immune response directed against RBC surface antigens - intra-vascular (high levels of antibody and/or complement fixation) or extravascular haemolysis. (antibody attachment - cell membrane damage - rapid clearance in the spleen and liver)
- Most cases are regenerative anemia , However some can results in Non reg Anemia

Classifications

- Warm Antibody Type Agglutination- Acute severe extravascular hemolysis.
- Warm Antibody Type -Intravascular Hemolysis
- Warm Antibody Type Incomplete Antibody- Extravascular hemolysis, without autoagglutination or hemoglobinemia.
- Cold Antibody Type Agglutination- No agglutination at body temperature. -ischemic necrosis of the ear or tail tips, the end of the nose, and the feet.
- Cold Antibody Type Non agglutinating Hemolysis- Hemolysis may occur within the extremities - transient hemoglobinemia and hemoglobinuria.
- IMHA occurs when the host produces IgG or IgM autoantibodies against its own red blood cells. Complements also. Immune self-tolerance and/or dysregulation of B cell activity, T cell activity, and macrophage reactivity occurs. Regulatory T cell dysfunction; defective development of peripheral or central tolerance; cross-reactivity between self and foreign antigens; and exposure to previously hidden self-antigens.

Signs of IMHA

- Lethargy, weakness, pale mucous membranes, and a hemic heart murmur
- achypnea, tachycardia, and bounding pulses
- Hyperbilirubinemia, bilirubinuria, and tissue jaundice -acute, severe IMHA
- Many patients with mild to moderate IMHA never become clinically icteric
- Pulmonary thromboembolism (PTE) -acute severe anemia on high-dose glucocorticoids

Triggers for IMHA (Whitley (2019) December IN PRACTICE)

- Up to 85 percent of dogs with babesiosis will have a positive Coombs' test attesting to the immune mediated nature of the anemia. (Birkenheuer, 2006 ACVIM)
- No consistent evidence exists that vaccination increases the incidence of IMHA in the general population

Infections	Dog	Cat
	Lepto, Dental, Pyometra	Pyothorax, FIV/FeLV, FIP
Vector borne	**Babesia** canis/gibsoni, Anaplasma, E canis	Mycoplasma haemofelis and Mycoplasma haemominutum. Cytouxzzon felis
Neoplasm	LSA, Histiocytic Neoplasia, Leukemia hemangiosarcoma,	LSA
Inflammation	Pancreatitis, SLE	Pancreatitis
Drugs	Cephalosporins,TS, Human erythropoietin	Methamizole, Varbimizole
Recent Vaccination	??	??

	Acute or chronic	Thrombocy topenia	Anemia	**IMHA**	Polyarthritis	Proteinuria
Ehrlichia	A or C	Y	Y	Rare	+/-	+/-
Anaplasma phagocytophilum	A	Y	Y	Rare	+/-	+/-?
Anaplasma platys	**A or C**	**Y**	**N**	**N**	**N**	**N**
Babesia spp.	A or C	Y	Y	Y	N	Y
Rocky mountain spotted fever	A	Y	Y	N	Y	Y (but not GN)
Bartonella spp.	A or C	Y	Y	Y	Y	Y
Borrelia spp.	A or C	N	N	N	Y	Y
Leishmania spp.	C	Y	Y	N	Y	Y
Hepatozoon spp.	C	N	Y	Y	Y (look alike)	Y
Hemotropic Mycoplasma spp.	A or C	N	Y	Y	N	N

Birkenheuer ,Southwest Veterinary Symposium 2017

Evans syndrome

- Approximately 50% to 70% of dogs with IMHA have concurrent thrombocytopenia known as Evans syndrome.
- Petechiae, ecchymoses, and melena
- Immune-mediated platelet destruction and platelet consumption due to DIC - as differentials in cases of concurrent hemolytic anemia and thrombocytopenia.
- Only two retrospective studies in dogs (Goggs and others 2008, Orcutt and others 2010)

Approach

Reticulocyte count

- Normal count : Dog 0-1%, Cats up to 2%

PCV		MF
45		1
35		1.5
25		2
15		2.5

- First correction required : Corrected RC • Example : PCV of 25%, Ret count 8%. Normal = 45
- Corrected ret count 8 X 25/45 = 4.4
- Regenerative Anaemia = > 1 o > 3 always indicate Haemolytic o >1 and <3 = Blood loss
- Second correction required – Reticulocyte index
- Reticulocyte Index : = Corrected Ret count/MF
- Above Example : 4.4/2 = 2

- Non-regenerative anaemia = < 1
  - **40% to 89% of dogs with IMHA are positive for Slide agglutination test**
  - **Spherocytosis has been identified in 89% to 95% of dogs with IMHA**

	Blood loss	**Hemolytic**
Serum Proteins	N to L	N to H
Bleeding	common	Rare(except Ecanis)
Icterus	No	common
Hbnuria	No	common
Spherocytes	No	common
Red cell inclusion	No	Occasional
Splenomegaly	No	common
Direct coombs	Negative	Usually +ve
Autoagglutinaton	No	Occasional
Hemosiderinuria	No	Yes

Diagnosis

- Anemia with presence of at least two indicators of immune-mediated destruction (spherocytes, positive slide agglutination test, positive Coombs test, or detection of IgG against canine RBCs by flow cytometry) with at least one indicator of hemolysis (hyperbilirubinemia, significant bilirubinuria, hemoglobinemia/hemoglobinuria, or ghost cells) and the absence of another obvious cause of anemia.
- A dog with hyperbilirubinemia and a positive slide agglutination, without other supportive evidence, would be classified as having 'supportive' evidence of IMHA but would not be considered a definitive diagnosis
- Dogs with idiopathic IMHA have significantly higher % IgG binding than dogs with other causes of anemia. (flow cytometry Assay)

Step 1 > 2 signs (ACVIM conseus J Vet Intern Med. 2019;33:313–334)

- Spherocytes(Dogs)
- Positive SAT
- Positive Direct antiglobulinTest (DAT) or Flow Cytometry (FC)
- Or
- Positive SAT that persist after washing

IF YES

> One sign of hemolysis

- Increased Bilirubin or Bilirubin or icterus without Hepatic disease
- Hemoglobinemia
- Hemoglobinuria
- Erythrocyte Ghost Yes -Support IMHA
- No- Support if no other cause identified

IF NO

- One sign of Immune mediated destruction
- Spherocytes (dogs)
- Positive SAT without washing
- Positive DAT or FC
- No - Not IMHA
- Yes- See If Yes

Coombs Test (Pet biotech, IISC, Bangalore)

- Confirm Red cell-bound IgG, IgM, or complement C3
- Indirect Coombs' test - detects antibodies to RBCs in the serum
- Direct Coombs' test- detects antibodies attached to RBCs-
- Sensitivity 60-89%
- The sample required for a Coombs test is 2–5 ml EDTA sample

Management

- Blood transfusion (PCV < 20 or 12-16 ??)
- Fresh pRBC, ideally no older than 7-10 days, are recommendedbecause RBC age is associated with mortality risk in dogs with hemolysis.
- Older units may be associated with a greater risk of complications and increased mortality. Prefer over Bovine hemoglobin solutions (BHS) or No benefit of Fresh frozen Plasma

Therapy

- Prednisolone: 40 mg/m2 p.o. q24h (<10 kg body weight, 2 mg/kg p.o. q24h) and Azathioprine (2 mg/kg p.o. q24h) are preferred to prednisolone on its own.
- Dexamethasone (0.3–0.5 mg/kg i.v. q24h) may be substituted for prednisolone
- Typically 3-6 months of steroids treatment in the majority of cases, with an expected duration of 4-8 months for all immunosuppressive treatment.
- Decision to add 2nd or 3rd drug – poor response in a week time
- Dogs weighing more than 25 Kg likely to develop adverse effects – consider single dose in a day or use equivalent dexamethasone ? consider using second drug ?

EXAMPLE FOR 20 KG DOG

- 20 mg prednisolone Q 24 hours for 2 weeks
- 15 mg Q 24 hours for two weeks
- 10 mg Q 24 hours for two weeks
- 5 mg Q 24 hours for two weeks
- 2.5 mg Q 24 hours for two weeks
- 2.5 mg Q 48 hours for two weeks, Then discontinue.
- Gastroprotectant therapy – use only in demonstrable gastrointestinal ulceration or bleeding or in those with other risk factors like liver disease, inflammatory bowel disease, or pancreatitis

Second/Third drug for IMHA

- Azathioprine - synthetic imidazole -acts to diminish lymphocyte number and T-cell–dependent antibody synthesis through disruption of the purine synthesis required for DNA and RNA replication
- Azathioprine: 2 mg/kg or 50 mg/m2 PO q24h. is typically well tolerated when dosed at 2 mg/kg PO q 24 h as a loading dose and then often tapered long term to 0.5–1 mg/kg PO q 24–48 h. After 2-3 weeks, the dosing interval may be increased to every other day until treatment is discontinued. studies did find any benefit on outcome when used with steroid.
- Cyclosporine: 5 mg/kg PO q12h. Cyclosporine bioavailability varies significantly between different formulations, and only modified (microemulsified) cyclosporine should be used. Some dogs may develop marked immunosuppression and possibly from ABCB1 (‘MDR1’) gene mutation. Few controlled studies did find any benefit on outcome or survival when used with steroid.
- Mycophenolate mofetil: 8-12 mg/kg PO q12h.
- IV immunoglobulin (IVIG) -0.5-1g/kg as a single infusion -not responding to treatment with 2 immunosuppressive drugs. Few studies. One controlled study did not find any improvement or effect on duration of therapy.

Mycophenolate – when ?

- Noncompetitive, selective, and reversible inhibitor of inosine 50-monophosphate dehydrogenase (IMPDH). Inhibition of IMPDH prevents proliferation of both B- and T-lymphocytes by preventing de novo guanine nucleotide synthesis
- Mycophenolate mofetil is often well tolerated at doses 10 mg/kg PO q 12, but severe gastrointestinal complications may be seen in some dogs
- Unable to tolerate oral medications- AZT
- Rapid (>10% in 24 hours) fall in PCV
- Spontaneous agglutination,
- Spontaneous intravascular hemolysis
- Pancreatitis

When to stop therapy

- Most dogs will require 3 to 6 months of treatment. Second-line immunosuppressive drugs are typically stopped once the glucocorticoids are discontinued provided the disease remains in remission. Abrupt, premature, or rapid dose deescalation can trigger relapse
- Success are those cases with stable PCV greater than 30% for 2 weeks including disappearance of agglutination and spherocytosis and reductions in serum bilirubin concentration.
- The first dose reductions are typically 20% to 25% and can be reduced much faster by 25-50% If a second immunosuppressive drug was initiated

Relapsing cases

Reports of relapses ranged from 25/154 dogs to 22% with a median of 517 days in another study. In a Recent study (Sidney 2024) shown that a lower PCV at diagnosis was not associated with an increased risk of relapse, while a higher total bilirubin was associated with a significantly increased risk of relapse

- Go back to original dose
- If this is ineffective - no response in a week or increase in PCV by <5% within 6 days, or progressive deterioration - Cyclosporin (5–7.5 mg/kg p.o. q24h) may be beneficial.
- If there is no response to the Cyclosporin within 5 days and/or deteriorate - Consider immunoglobulin (0.5–1.0 g/ kg i.v. over 6–8 hours).
- if long-term control is necessary or all drugs failed - leflunomide (4 mg/kg p.o. q24h).
- When the PCV/Hct has remained stable and >30% for 2 weeks after commencing treatment,
- Dose reductions should not be made more frequently than once every two weeks
- Recommend decreasing the dosage of prednisolone by 25%.
- If PCV stable- decrease further by 25% every 3 weeks
- If a second drug has been introduced to avoid adverse effects of steroids -the dosage of this drug should not be changed- only one drug should be reduced at a time

Thromboprophylaxis and **Antiplatelet therapy**

- Good evidence indicates that IMHA in dogs is associated with an increased risk of thrombosis. Venous thrombosis, particularly pulmonary thromboembolism, is an important cause of morbidity and mortality in IMHA. Thromboprophylaxis is therefore crucial for management of canine IMHA.
- Mechanism of thrmobosis – Multifactorial- intravascular expression of tissue factor, endothelial activation, and the release of procoagulant microparticles. Imbalance of pro- and anticoagulant factors , secondary platelet activation. Neutrophil extracellular trap formation.
- Prothrombotic, with high levels of activated platelets, increased amounts of tissue factor and phosphatidylserine-positive microparticles, and thromboelastographic markers suggestive of hypercoagulability
- Autoagglutination and intravascular hemolysis. leukocytosis and hepatopathy and Administration of high-dose glucocorticoids and IVIG likely increases the risk of thrombosis. DIC reported but uncommon
- initiated at the time of diagnosis and continued until the patient is in remission and no longer receiving prednisone or prednisolone.
- In IMHA, thrombocytopenia with platelet counts greater than 30,000/mL likely represents a consumptive process
- It is generally agreed upon that anti-coagulant and/or anti-platelet drugs should be administered as part of routine treatment- Thromboprophylaxis be provided for all except those with severe thrombocytopenia (platelet count <30 000/μL).
- Given the risk of thrombosis, administration of an antiplatelet agent is preferable to no antithrombotic therapy
- Unfractionated heparin (IV): 100 U/kg bolus, then 900 U/kg/24 h - there is evidence to suggest a reduction in case fatality rates in dogs with individually-adjusted dosing (median dose 360 units/kg) compared to those who received a constant dose of 150 units/kg SQ q 6–8
- Unfractionated heparin (SC): 150-300 U/kg q6h
- Dalteparin (SC): 150-175 U/kg q8h
- Enoxaparin (SC): 0.8-1.0 mg/kg q6-8h
- Rivaroxaban (PO): 1-2 mg/kg q24h - direct factor Xa inhibitor , used without any major adverse effects reported. This medication appears to be safe and well-tolerated in dogs with IMHA

- Antiplatelet agent - **Clopidogrel 1.1-4.0 mg/kg PO q24h**. platelet P2Y12 receptor inhibitor, is commonly used as single agent antithrombotic therapy. safe and to have similar short-term survival when used either alone or in conjunction with ultra-low dose aspirin in dogs with IMHA.
- Aspirin 1-2 mg/kg q24h – irreversible inhibition of platelet thromboxane A2 production . can be combined with clopidogrel

In a recent study on 242 pets with IMHA, use of pred alone vs. a multi drug immunosuppressive protocol had no effect on time to PCV stabilization or duration of hospitalization rate. Case fatality with single drug was 17.6% vs 28.3% using 2 drugs. However, the authors recommended more than one drug for dogs weighing >25 kg. In the same study the use of clopidogrel vs a multi-agent protocol was not significantly different with regards to development of thrombi, Likewise, the use of an anti-platelet vs an anticoagulant drug protocol was not significantly different with regards to the development of a definitive thrombus Weng et al (2023) J Vet Intern Med. 2023;37(2):528–536).

Splenectomy - Second-line treatment strategy in human medicine for cases of hemolytic anemia with either a lack of response to and/or significant adverse effects from corticosteroids. - remove both the major site of extravascular hemolysis and a contributing source of antibody-producing B-lymphocyte production. Few reports avialable in veterinary medicine (one retrospective showed better outcome) however, splenectomy may be considered in cases who fail to respond to traditional therapy and remain transfusion dependent. immunosuppressive and antithrombotic medications may need to be discontinued or reduced

Therapeutic Plasma Exchange - help to remove circulating autoantibodies and reduce severe hyperbilirubinemia. relatively safe and feasible option where available No Specific recommendations available at this moment.

- Other under investigations : liposomal clodronate, melatonin, hyperbaric oxygen therapy (HBOT),
- Monoclonal antibodies - Rituximab - binds the cell surface CD20 expressed on B-lymphocytes leading to complement and antibody-mediated cytotoxicity and the specific depletion of B-cells throughout the body. Specific for human and not dogs. caninized Mab against CD20 developed but found to be not so specific. Elanco,which along with Kindred Biosciences are reportedly working on this area.
- Complement inhibitors like C1-INH (C1 esterase inhibitor) might be an effective treatment of canine IMHA,

Prognosis

Several studies have documented 50-88% survival rate to hospital discharge. In another two studies of IMHA dogs with nonregenerative anemia , the median survival time was 50 and 277 days. Increased mortality was associated with increased BUN and increased AST hyperbilirubinemia, autoagglutination, increased band neutrophil counts, thrombocytopenia, and hypoalbuminemia. Thromboembolic disease was most common cause of death

Further reading

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Neonatal Care: They are not just born to die !! Medical management of Sick Neonatal puppies : Practical Tips

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Suggested Pediatric age group
Neonate: 0–2 weeks of age, Infant: 2–6 weeks of age, Juvenile: 6–12 weeks of age

The causes of neonatal illness, commonly referred to as fading puppy syndrome (FPS)/ or Mortality, are many. Overall neonatal mortality in puppies varies from 12% to 36% in both closed breeding colonies and in breeders' homes. Of the 27 litters examined, the total mortality rate, including stillbirths, was 23.07%, the early neonatal mortality rate (up to 7 days) was 14.42%, and the late neonatal mortality rate (up to 30 days) was 9.6% in a study (Vassalo et al (2015) Topics in Companion Med 30,16–21) The rate of stillbirths averages 12.9% with a range of 4.7 - 22.1% in cats. Greatest incidence of mortality occurs within the first week of life. Overall mortality by weaning at 8-12 weeks of age averages 23.2% in kittens and 18.7% in puppies.

Mortality occurs most frequently during the first week of life, as much as 75% of all neonatal disease and deaths occur at this time. Causes of fading puppy syndrome can be divided into three groups: environmental, genetic, and infectious. Congenital anomalies, including stillbirth, may account for up to 40% of early puppy deaths. It is sometimes difficult to differentiate congenital from acquired disease. Maternal neglect, Trauma, Obesity and age of bitch (Neonatal mortality increases as age of bitch advances) has significant effect on mortality.

Breeding of siblings or continued line breeding results in increased mortality rates when the COI (coefficient of inbreeding) is greater than 0.375.. Pedigree software programs to determine the COI are readily available with databases for a variety of breeds (www.tenset.co.uk; Or www.breedmate.com). In addition, Gross abnormalities, Low birth weight, Thymic dysfunction also contribute to FPS particularly during first few weeks of age

1. **Collect complete History :** Whelping (Location and temperature), appetite, parasite control, diet, vaccinations, mothering skills, and any medications. Family history of neonatal survival and weight gain since birth Nursing and activity of the litter

   If you have a Fetal Doppler : If the fetal HRs are normal (> 170, usually 180-220) you know they should resuscitate readily, while fetuses with HRs between 150-170 are going to need a lot of effort. Those with HRs 150 or less will need all the help you can give them. This lets you know to be prepared to go all out with those neonates.

   Puppies and C section :

   - Current evidence shows that propofol with isoflurane or sevoflurane was the most successful with regards to limiting neonatal mortality after C-section.
   - Safe analgesics for mother : Buprenorphine, tramadol, acupuncture.
   - Safe antibiotics : augmentin,, cephalexins, and enrofloxin (up to 4 wks of age) are safe.
   - Dog attachment pheromone is a natural chemical found in the amniotic fluid of dogs and is also produced by the lactating mammary gland of the bitch. This pheromone stimulates attachment of the dam to the pups and vice versa. With C-sections, the dam misses this key stimulant and that is one reason why bitches take so long to start good mothering after C-sections. DAP, or dog appeasement pheromone, is a synthetic version. It comes in diffusers, which take 72 hours to equilibrate in a room, a spray that dissipates in a couple hours (and contains alcohol), and a handy collar that lasts for about 4 weeks.
   - Swinging neonates is no longer recommended. Very vigorous rubbing of the neonate's dorsum is preferred. Swinging them risks trauma to the brain and also aspiration of stomach contents
   - Mucus traps are more effective than bulb syringes at suctioning fluids from airways. (see heart and resp rate for more details)
   - Doxapram should only be given to well-oxygenated neonates and never sublingually. Use the umbilical vein instead. (see heart and resp rate for more details)

2. **Examination of Neonates :** You require electronic weighing scale, stethoscope, thermometer, Vials for samples (blood, urine and fecal) collection and a Glucometer. Physical examination is similar to adults covering all the systems Place thick warmed towel or blanket over the examination table surface. Some vets use pheromone products in the examination room that may help calm the bitch and offspring. Neonates that are observed to lie apart from littermates or the dam, that cry excessively, are extremely restless, or that are recumbent must be examined immediately. The deciduous teeth are present by 6 weeks of age. Permanent teeth erupt, displacing the deciduous teeth, at 4-6 months of age. The dried umbilical cord normally is lost (falls off or rem0ved by dam)at 2 or 3 days of age. The umbilicus should be examined for evidence of infection. Look carefully for congenital defects such as cleft palates, pectus excavatum and atresia ani. Puppies and kittens can lift their head at birth. They crawl for the first 7-14 days of life, and should be able to support weight on their forelimbs by 10 days of age. Locomotion is present by 3 weeks of age. Neurologic examination of pediatric patients is possible at birth, but neurologic function does not mature until 6-8 weeks of age.
    - **Body Temperature :** 95° F–98° F for the first week, 97° F–100° F for next 3 weeks
    - **Heart Rate :** 200–220 beats/min first 2 weeks and 100–140 beats/min for next 2 weeks
    - **Respiratory Rate :** 15–36 breaths/min for first 2 weeks, 16–32 breaths/min for next 2 weeks
    - **Total body water (TBW)** for neonates is approximately 75-80% of body weight with an extracellular component of 45-50% of body weight.
    - Estimated **blood volumes** are 9% of body weight or 70-90 ml/kg. Ex. 400g pup, TBW= 300 ml, blood volume= 36 mL.
    - **Stomach Capacity :** 50 to 80 mL/kg daily or 4–5 mL/100 g BW
    - **Calorie requirement :** Dogs: 20–26 kcal/100 g BW/day Cats: 15–25 kcal/100 g BW/day
    - **Body weight :** Generally puppies gain a weight of 2 - 4 (7) grams per kg of adult body weight per day or 5-10% of its birth weight each day. Double weight in 10-12days. Pom 120g, Beagle 250g, GD 625 g. Kittens should gain 7–10 g/day

Drugs and neonates – some key considerations

- Poor absorption IM inj-Decreased vascular supply and small muscle mass
- Hypothermic puppies often have delayed intestinal absorption.
- Increased intestinal permeability for the first few weeks of life –rapid oral obsobtion
- Intraosseous drug administration is often used, and absorption is rapid by this route- All fluids that can be given intravenously can also be given intraosseously at the same dose and rate.- greater trochanter of the femur, the tibial tuberosity, the medial process of the proximal tibia, and the greater tubercle of the proximal humerus.
- High water content, Low Plasma protein - lower affinity to bind many drugs,
- The blood-brain barrier is more permeable for the first several weeks of life.
- Reduced glomerular filtration rate and tubular secretion in the kidneys.
- Hepatic metabolism is also immature - Drug clearance does not generally reach adult capacity until about 12 weeks of age

CBC in Neonates

- The PCV may be high at birth and reach adult normal range by 2 to 6 months of age.
- WBC count, Neutrophil and lymphocyte counts are relatively high at birth, decline during the first month of life, increase by the second month, and then slowly decline For puppies

Neonatal Kidneys

- The Neonatal kidney –immature both morphologically and functionally and nephrogenesis continuing for at least 2 weeks after birth.
- Renal function nears that of adult by 8 weeks of age
- The Creatinine levels are high In neonatal puppies between 1 and 3 days of age and gradual decrease occurs until 28 to 33 days of age followed by a slight increase at 7 to 8 weeks of age.
- Canine neonates have a low GFR, low renal plasma flow, exaggerated proximal tubule natriuresis and low concentrating ability. GFR and RBF increases 7 and 4 -fold over the first month of life respectively and reaches adult values approximately 10 weeks after birth
- Low urine specific gravity (1.006–1.017) is normal, and reach to adult dog by 6 to 8 weeks of age
- Glucosuria can be normal in puppies up to 8 weeks of age.
- Susceptible to drug toxicity that depend on renal excretory mechanisms because of their limited capacity to eliminate those drugs and drug metabolites

Neonatal Liver

- The liver has reduced capacities for most functions and has lower alternate source of energy from other sources
- Hepatic function nears that of adult by 5 months of age
- ALP, AST, GGT, CK are usually markedly increase during the first 24 hours of life and persist 10 to 14 days postpartum
- ALP activities are more than 30 times higher than adult values, primarily because of high levels of ALP in colostrum
- Total protein and albumin concentrations in young dogs up to 4 weeks of age are below normal adult ranges,
- Glucose, blood urea nitrogen, and cholesterol may also be lower than in adult

Colostrum and Neonates

- Neonates born immunologically immature - Virtually no antibodies are transferred to canine and feline fetuses in utero
- Colostrum in puppies and kittens needs to be ingested within the first 24 and 16 hours of life, respectively.
- Antibodies can be provided by administration of pooled serum or plasma from any vaccinated adult of the same species, given orally (if <12 hours old) or subcutaneously (within the first 24 hours).
- Kittens is 15 mL of serum - 5-mL SC boluses at birth, at 12 hours, and at 24 hours.
- Puppies - 22 mL/kg SC of pooled adult serum; this can be given as split boluses

Focus on supportive care until underlying cause identified

A. First assess **Body weight :** Generally puppies gain a weight of 2-4 grams per kg of adult body weight per day or 5-10% of its birth weight each day. Body weight may drop in the first day of life (up to 10% of birth weight) due to dehydration, but after this point neonates should gain 5 10% of their birth weight daily. Weighing daily is better than weekly during first few weeks and it may help for higher survival rate than waiting for additional clinical signs to appear. (Tips – must double weight in 10-12days. Pom 120g, Beagle 250g, Great Dane 625 g). Kittens should gain 50-100 GM weekly. Birth weight is not influenced by sex of the neonate, and is more likely an indicator of inadequate intrauterine nutrition or congenital abnormalities than of prematurity. Puppies that lose greater than 10% of birth weight in the first day of life have a poor prognosis.

B. Body condition and responses : On palpation, neonates generally have full, firm bodies. Flaccidity or rigidity of muscles and limbs is indicative of distress. Three responses can help you assess the overall condition of the neonate.

- Newborns should have a suckle reflex immediately after birth (can be tested by placing a clean finger in the mouth),
- and they should “root” –,when one cups (Form a circle with your thumb and forefinger) a hand over the muzzle they should push into the circle, often rising up on their front legs.
- A healthy, awake neonate will immediately roll sternal when placed in dorsal recumbency. Lastly Rubbing over the lumbar area should evoke a squeal and squeezing the toes results in a head “bob”.

day of life have a poor prognosis.

If these reflexes are weak or absent check for the presence of hypothermia, hypoglycemia and dehydration

3. **Hypothermia :** Average Rectal temp immediately postpartum = 96 F. First week = 95 to 98 F, 2-3 weeks = 97 to 100 F, 4th week = match those in adults Hypothermia is a primary or contributing cause of many neonatal deaths. Hypothermia results in a decreased heart rate and circulatory collapse. In addition, hypothermic neonates do not nurse, are unable to digest food, and develop ileus. . Neonates whose temperatures fall to 94 F or below suffer ileus and marked bradycardia. Hypothermia quickly results in a deterioration of cardiovascular, respiratory, and gastrointestinal function, which can rapidly cause death. In suspected herpes virus infection keep body tem above 100 F. Warming should take place gradually, over one to four hours. Rapid warming may result in peripheral vasodilatation and core collapse. Management : Incubators, Room heaters, water pads and warm water bottles. Alternatively, a hair dryer set on “warm” can be gently moved over them to provide heat. Once the patient is warmed, the ambient temperature should be 85 to 95 F (29.4 to 35 C), with humidity at 55% to 65%.
   Environmental warmth required
   Week 1 : 84_F–89 F, Week 2/3 : 80 F, Week 4 : 69–75F, Week 5 : 69F

4. **Hypoglycemia and Dehydration :** Glycogen stores are depleted shortly after birth, making adequate nourishment from nursing vital. It has been estimated that in the absence of maternal milk up to 50% of glycogen reserves will be utilised by the neonate within three hours postpartum Hypoglycemia can also result from endotoxemia, septicemia, portosystemic shunts and glycogen storage abnormalities. Oral fluid and glucose replacement may be preferable if the puppy has an adequate swallowing reflex and is not clinically compromised. Early signs of hypoglycemia includes lethargy, decreased suckle, crying, and a limp body

   Asses hydration : skin turgor is not reliable in neonates. Pale mucous membranes with slow capillary refill time indicate 12% to 15% dehydration. Dehydrated pediatric animals exhibit more wrinkling and less turgor of the skin, and deepening of the red color of the ventral abdomen and muzzle. Other signs of dehydration include dryness of the eyes and oral mucous membranes, and visible yellow color of the normally dilute urine. Prerenal azotemia and concentrated urine specific gravity may not be present in neonates despite profound dehydration. Likewise heart rate and blood pressure are not reliable in assessing hypovolemia. For neonates, maintenance fluid requirements are 120–180 mL/kg/day, while for pediatric patients they range from 80–120 mL/kg/day.

   Management: Warmed isotonic dextrose solution through a stomach tube, then 1 to 2 ml 5% to 10% glucose solution can be administered orally /tube. 20% dextrose, 0.25 ml/25 g IV or intraosseous, up to 11 ml/min. Cats: Hypoglycemia: 1–3 mL/100 g of kitten with a 12.5% dextrose solution (e.g., 1:3 dilution of 50% dextrose).
   (lactated ringer's solution or Normal saline) and 5% dextrose may be administered subcutaneously at a dose of 1 ml per 30 g of body weight, until the pup can be fed or nurses. A balanced warmed nutrient-electrolyte solution can be administered orally by stomach tube every 15-30 minutes until the neonate is capable of suckling. 50% dextrose solution should only be applied to the mucous membranes because of the potential for phlebitis if administered intravenously; however, circulation must be adequate for absorption from the mucosa. Intra peritoneal not very useful. All fluids that can be given intravenously can also be given intraosseously at the same dose and rate.-

Crystalloids Bolus

- Puppies- 3 to 4 mL/100 g
- Kittens -2 to 3 mL/100 g

Colloid bolus - nonresponsive to crystalloid

- 2 mL/kg to 5 mL/kg – then-1 mL/kg/h as needed

Whole blood for anemia

- 10 mL/kg to 20 mL/kg

Colloids : Hetastarch/dextran 70 - can also be tried 1 mL/kg/h or plasma can be used to keep COP above 15 mm Hg as puppies have lower COP than adults
Vitamin K : 0.5 to 2.5 mg/kg subcutaneously in neonates less than 3 days of age

5. **Nutrition**

Do not feed hypothermic neonates as they can not digest to absorb food efficiently. Tube feeding is the ideal route for ill or orphaned neonates.
Management : Warm the milk replacer to normal body temperature, around 95–96°F. Puppies like sweet things so if they are a little reluctant to take the bottle, use just a little bit of corn syrup or honey on the nipple. Try to keep them on their belly, have the milk replacer at body temperature, use a nipple of a size they can handle, and you should not have to worry about aspiration problems.

Tube feeding in very sick and hypothermic puppies : Use the largest French red-rubber feeding tube and Measure from the tip of the neonate's nose to its last rib with the head in an extended position, and mark this length on the tube. This is where the tube must reach to be securely in the stomach. 5- to 8-Fr feeding tube -Passing the tube down the left side of the throat will help ensure that the tube is placed in the esophagus rather than the trachea. Remember that Puppies and kittens do not develop a gag reflex until about 10 days of –therefore cannot be used to assess whether the tube has entered the esophagus. Confirm proper placement of the feeding tube radiographically or by instilling a small amount of saline solution; if the saline exits the neonate's nose, the tube is in the trachea.

The neonatal caloric requirement is 133 calories/kg/day during the first week of life, 155 calories/kg/day for the second, 175 - 198 calories/kg/day for the third and 220 calories/kg/day for the fourth. Follow the directions of tube feeding/puppy milk or orphan formula considering calorie density. In general, feed 22 to 26 kcal/100 g/day. Feed every two hours. Once stable and active - Use bottles and nipples for premature infants

More than 90% of maternal antibodies are passed to the neonate via the colostrum. Nursing must happen 2-3 hours after birth- max absorption up to 8 hours- decrease significantly by 24 hours. Serum IgG concentrations are low at birth, increase rapidly to a peak 18 hours after ingestion of colostrum, and then decline to a nadir at 3-4 weeks of age. Colostrum or serum replacement can be given orally during the first 24 hours of life; thereafter, it must be given parenterally and intestinal absorption of macromolecules is compromised. The subcutaneous route is preferred to intraperitoneal administration. **Puppies serum ALP and GGT Concentrations can be used as marker for adequate colostrum intake**. Remain high for only for 1-2 days in puppies and kittens that have ingested colostrum and low in puppies that have not ingested colostrum

Puppies that do not receive colostrum, passive antibodies can be provided by using serum from healthy, well-vaccinated donors. 16 -22ml per kg pooled serum can be given subcutaneously,either slowly or in multiple doses over 24 hours or about 5–7 ml of colostrum orally and repeat it one or two times.. However, colostrum deprived puppies given 40 ml/kg adult dog serum orally and parentally failed to match suckling littermate's IgG levels in a study. Bovine/caprine colostrums (present in Pedigree Mother and Pup) will not provide any passive antibody protection but it may supply important nutritional and growth components to the Gut.

A. Biologically active factors present in Bovine colostrum

1. Immunoglobulins (antibodies) : IgA,IgG & IgM
2. Growth factors
    - Insulin-like growth factor
    - Transforming growth factors
    - Growth hormone
3. Immune factors
    - Lactoferrin
    - Lysosyme
    - Cytokines
    - Lymphokines
4. Oligopolysaccharides
    - Complex sugars that attract and bind pathogenic bacteria

B. Immune factors present in Bovine colostrum

Lactoferrin

- An iron-binding protein
- Highly resistant to digestion
- Antiviral and antibacterial properties (non-specific)
- Inhibits the growth of bacterial pathogens and promotes the growth of beneficial bacteria

Oligopolysaccharides and Glycoconjugates

- Complex sugars
- Attract and bind pathogenic bacteria, preventing them from crossing the mucosal wall
- Shown to block pathogens such as salmonella and clostridia

C. Antibacterial substances in Bovine colostrum

- Bacteriostatic properties
- Inhibits the growth of E.coli in vitro
- High capacity for neutralising bacterial toxins
- Inhibits the adhesion of bacteria to gut mucosal cells

6. **Respiration and Heart rate :** Heart rates are usually around 150-220 beats/min during the first week of life, with respiratory rates of 10 to 35 breaths/min. These gradually decrease to normal adult heart and respiratory rates by 4 weeks of age. Functional murmurs may be heard in anemic or ill neonates. Likewise Innocent murmurs not associated with disease or anomalies are common, particularly in large- and giant-breed dogs. Bradycardia is associated with hypoxemia in neonates. Cardiac murmurs of grade I-III / VI, most commonly heard at the base of the heart on the left side, are often functional murmurs due to anemia, hypoproteinemia, fever or sepsis. Congenital cardiac abnormalities usually are associated with murmurs of grade III-VI / VI and abnormal peripheral pulses. Clinical signs associated with pathologic murmurs include poor growth, lethargy, cough, dyspnea and cyanosis.
   The nasal and oral passages must be cleared using an infant suction bulb which can be purchased at most drug stores. Delee Mucus traps are choice and safest - These cost between $3 and $4 each and are very safe as the silastic tubing is quite soft and will not puncture a neonatal trachea. They reach well down into the airways and also into nares of all but the smallest neonates. You can search them on the web - they can be purchased from a number of human medical suppliers.

Can be used in both nostrils and the trachea probably get down to the bifurcation, suctioning from all areas. Amount of mucus drawn may range from 1-3 ml. If you use a hard catheter or other utensil to suction from the trachea- may damage frafile tissue laryngeal paralysis .
In smaller puppies, a cotton-tipped swab may be all that is needed to clear foetal fluids from the pharynx. If the newborn has a normal heart rate (150 to 220 beats/min) but is apnoeic, tactile stimulation and oxygen administration by a facemask may be effective in initiating respiration. If no response within 30 seconds or the heart rate begins to decrease, positive pressure should be applied by facemask to expand the lungs (The head in an extended position and tightly fitted mask)
Intranasal oxygen is an excellent way to oxygenate ill neonates. Use a small French feeding tube with multiple holes placed. For patients less than 10 kg, administering humidified oxygen at a flow rate of 40 ml/min/kg will result in a tracheal oxygen concentration of 40% (Do not exceed 40% to 60% to avoid oxygen toxicity)

Doxapram is believed to work via both central stimulation and stimulation of the carotid chemoreceptors. It is not effective unless the brain is oxygenated. It also can decrease cerebral blood flow. Hence, doxapram is unlikely to be of much benefit in the apnoeic, hypoxic newborn and its routine use is questionable, although vets place a drop or two under tongue. If you use doxapram in a ventilated neonate, inject it into the umbilical vein and follow with a small saline chaser to ensure it enters the circulation. Dose : 1-2.5 mg per puppy.

Acupuncture in the philtrum? : use GV 26 (acupuncture point at philtrum) - shown to increase BP. Use acupuncture needle or you can use a 25 g needle and peck it repeatedly off the bone.

Heart rate : if HR is low or absent , Epinephrine at a “low dose” (0.01-0.03 mg/kg or 10 ug/kg IV and increase if there is no response) into the umbilical vein, via an endotracheal tube or by the intra-osseous route (proximal humerus or femur) should be used if there is no heartbeat. Epinephrine will increase mean blood pressure and improve myocardial oxygen delivery. Atropine was once commonly used, if no heartbeat or if bradycardia was noted. The bradycardia in the neonate is essentially always due to hypoxia. Hypoxia in the neonate is due to direct depression rather than vagally mediated, so atropine is not useful. **Atropine is actually contraindicated in this instance**, as it will increase the myocardial oxygen demand and make things worse for the neonate. Naloxone can be used via umbilical vein, if Bradycardia is drug induced or via Naloxone can be given at a dose of 0.1 mg/kg intravenously, intraosseously, intramuscularly, subcutaneously, sublingually, or by endotracheal administration

Summary of neonatal resuscitation

- Heat source, Vigorous stimulation , DeLee mucus trap work 100%
- Intubated – Oxygen- any neonate not rapidly resuscitated with stimulation, warmth and airway clearing.
- Epinephrine - only neonates who have no heartbeat when ventilated on oxygen, stimulated, etc.
- Doxapram and Anticholinergic not always beneficial
- Glucose - not useful in acute situation.

7. Infections and drugs in Neonates

Infectious causes : Neonatal septicemia results from systemic bacterial infection. Because of their immature immune systems, puppies and kittens are at risk for infection through the placenta, umbilicus, or gastrointestinal or respiratory tract from contaminated environments

Bacterial : includes Brucella canis, E.coli, camplylobacter sp, Staph , streptococcus sp, Bordetella broncospetica, Mycoplsma. The organisms most frequently associated with septicemia are E.coli, streptococci, staphylococci, and Klebsiella spp. Pre-mortem diagnosis can be challenging, clinical signs may not be noted due to sudden death. Commonly, a decrease in weight gain, failure to suckle, hematuria, persistent diarrhea, unusual vocalization, abdominal distension and pain, and sloughing of the extremities indicate septicemia may be present.

Viral : In puppies, canine herpesvirus infection is a frequent cause of neonatal morbidity and mortality. Herpesvirus is a mild endemic respiratory virus in adult dogs, but it causes abortion and early neonatal death when contracted by a bitch during the last three weeks of gestation and neonatal illness and death when pups are exposed in the birth canal or during the first three weeks of life. Clinical signs include constant crying and abdominal pain; acute death also occurs. Necropsy reveals petechiation of the kidneys, liver, and intestines, and infection is confirmed with virus isolation. Nested polymerase chain reaction testing has also been used to document canine herpesvirus infection and is available from a number of sources. A canine herpesvirus vaccine is available in Europe and Other viral causes are Parvo, hepatitis and distemper

Parasitic : Ascarids, Giardia sp. Roundworms and Hookworms are transmitted transplacentally, most pups are born with these parasites. Roundworm larvae are also transmitted in the milk during nursing in puppies.

Both Babesia canis and Babesia gibsoni are known to be transmitted transplacentally in dogs- signs includes lethargy, poor body condition, pale and icteric mucous membranes, splenomegaly, tachycardia, heart murmur, anemia, and thrombocytopenia- Imidocarb dipropi onate, atovaquone and azithromycin and 4 Drugs combo etc. Neospora caninum ,Leishmaniasis and Dirofilarial microfilariae are also reported to be transmitted transplacentally

"**Toxic milk syndrome**" - increased vocalization and abdominal distension in 3-14 day old puppies or kittens - more likely to be due to hypothermia with secondary ileus or to overfeeding than to abnormalities of the dam's milk. This is more likely to be **due to hypothermia with secondary ileus or to overfeeding than to abnormalities of the dam's milk .**

Fading puppy syndrome - The term fading puppy syndrome (FPS) or fading puppy complex has been used inconsistently to refer to any failure-to-thrive syndrome beginning from birth to weaning that results in death despite all attempts at treatment. However, the term 'fading' has been mostly applied to neonatal puppies.
Developmental Lung disease ?? Research at Oregon state university suggested that FPS can be form of Underdeveloped alveoli, Pul artery Medial hypertrophy, AV shunt like vessels ??
The neonatal period has been defined variously as the first seven or 10 or 21 days. The causes are many Infectious and noninfectious - include all the factors discussed above including neonatal isoerythrolysis in cats. The primary factors like hypothermia, poor colostrum ingestion predispose neonates to secondary infection with subsequent hypoglycemia and dehydration leading to cardiopulmonary failure. Other hypothesized causes include poor thymic development with abnormal development or maturation of T cells, undefined hereditary factors, abnormalities of surfactant causing inability of the neonate to breathe and suckle normally.

Management: Some physiologic differences affect drug use in neonatal patients. Some differences are absorption thru IM and SC routes, Low level of albumin as well as binding, high water content, poorly developed BBB, Reduced GFR and hepatic metabolism.

- Safe antibiotics for use in Neonatal bacterial septicemia includes cephalosporins (Ceftiofur sodium should be 2.5 mg/kg SC q 12 h for no longer than 5 days) Amoxicillin +/- clavulanate and macrolides (Azithromycn, tylosin).
- Cephaosporins and Pencillins- lengthen dosing interval slightly;
- Macrolides (erythromycin) and Lincosamides (Lincomycin and clindamycin)) –No change in dose or dosing interval
- Discourage use of amino glycosides (Gentamycin, kanamycin, streptomycin etc) and tetracyclines

- Metronidazole- decrease dose or increase dosing interval
- Rest of antibiotics should be used based on risk analysis. For eg., Enrofloxacin has been used succesfully in 4 week old puppies despite reported risk of cartilage damage.

In puppies, canine herpesvirus infection is a frequent cause of neonatal morbidity and mortality. In puppies with suspected canine herpesvirus infection, treatment with acyclovir (10 mg/kg orally every six hours for five days) can be successful
Pyrantel pamoate is still safest drug and can be started at 2 weeks of age.
Fenbendazole at a dosage of 50 mg/kg given orally daily from Day 40 of gestation to 14 days postpartum useful in Preventing larval migration from the dam to puppies (also used for giardiasis treatment) In swimmer neonates, the typical dorsoventral flattening and inability to walk are responsive to physical therapy. Pituitary-derived bovine growth hormone has been used successfully to treat thymic atrophy in a study.

Special Needs

Kittens and puppies under 3 weeks of age lack voluntary elimination and must have the micturition and defecation reflexes stimulated using a cotton ball with mineral oil on the anogenital area. Sibling suckling can cause dermatologic lesions, periodic separation of the neonates in an orphaned litter may be necessary until solid food is introduced

Apgar score suggested for puppies (after birth)

The evaluation of human neonates is performed based on the Apgar score, and is method most employed in the immediate identification of the status of the child at birth. The index is based on the evaluation of 5 vital clinical signs including heart rate, spontaneous breathing, muscle tone, grimace, and the appearance of the mucous membranes, and each criterion is evaluated on a numerical scale from 0-2. (Veronesi et al (2009) Theriogenology 72:401–407 , Abreu & Vannucchi (2016) 47 / Veterinary Focus / Vol 26, 1)

Parameter	Score 0	Score 1	Score 2
Heart rate	Absent	Bradycardia (< 200 bpm))	Normal (200-250 bpm
Respiratory effort and rate	No crying/Absent, < 6 rpm	Mild crying, Irregular (< 15 rpm)	Crying, Regular and vocalization rpm)
Muscle tone	Flaccid	Some flexion	Flexion Reflex
irritability	Absent	Some movement	Hyperactivity
Cyanosis and pallor	Cyanosis and pallor	Cyanosis/Pale	Pink

Score interpretation: Healthy : > 7, Need Assistance : 4 and 7 and Emergency Care : < 3

The mortality rate 2 hours after birth is higher in newborn canines with an Apgar score of 0-6 compared with those with a score between 7 and 10 in a study (Veronesi et al (2009) Theriogenology 72:401–407)

The Neonatal Viability Reflexes (Vassalo et al (2015) Topics in Companion Med 30,16–21)

Parameter	Weak(0 Score)	Moderate(1 Score)	Normal (2 Score)
Suckle	Absent	Weak >3suckles/min	Strong (5 suckles/min)
Rooting	Absent	Slow muzzle fitting inside the circle	Immediate fitting muzzle within the circle
Righting Reflexes	Absent (continues in initial position)	Slow body repositioning	Fast body repositioning

Score interpretation: 0-2, weak viability; 3 and 4 -moderate viability; and 5 and 6- normal viability

Some clinically relevant **Developmental benchmarks**

Milestones	Average age
Physical development:	
Eyes open	7 to 10 days
Ear canals open	14 days
The ability to shiver	After Day 6
Crawling	7-14dyas
Forelimb support	10 days
Primary teeth through	14 to 21 days
First adult roundworms (Toxacara canis) passed	14 days
Body twitching in sleep	0 to 28 days

Development of puppy skills	
Can see	10 to 15 days
Barking	18 days
Early play movements	18 to 20 days
Stand upright	21 days
Urinate and defecate without stimulation by bitch	21 days
Balance for passing urine and bowel movement	21 to 26 days
Eat from dish	24 to 27 days
Play with other pups	25 to 28 days
Walk and run	28 days
Sight as good as adult	28 days
Hearing acute	35 days
Play with toys	35 days
Play constructively with litter mates	40 days
Learning mouth and paw skills and body control	40 to 48 days
Voluntary control of urination and defecation	Begins at 10 to 12 weeks – perfected at 4 to 6 months

TYPE	REPRESENTATIVE DRUG(S) AND EFFECTS
Anti convulsants	Primidone (cardiac defects, cleft palate, skeletal abnormalities)
Anti-infectives	Griseofulvin (microophthalmia [kittens], cleft palate [puppies])
	Ketoconazole
	Tetracycline and aminoglycoside antibiotics
	Metronidazole
Anti inflammatories	Aspirin
	Dimethylsulfoxide (DMSO)
	Glucocorticoids (anasarca in brachycephalic breeds)
Anti-neoplastic agents	
Hormones	Diethylstilbestrol (DES) and estradiol cypionate (ECP) (feminization of males)
	Testosterone and mibolerone (masculinization of females)
	Progesterone (masculinization of females)
Sedatives	Diazepam and midazolam
Vitamin excess	**Vitamin A** /Retinoids(cleft palate, kinked tails, cardiac defects [kittens])
	Vitamin D (tissue calcinosis, enamel hypoplasia, cardiac defects)

First 26 days after conception -cephalic, ocular, otic, and/or cardiac abnormalities After 26 days : Palate, cerebellar, and/or urogenital defects.

Further reading and references available up on request;

Understanding Arterial Blood Gas Analysis in Critically ill dogs: Basics and clinical applications

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Blood gas analysis plays a vital role in managing patients with respiratory and metabolic disorders, especially in emergency and critical care settings. This diagnostic tool helps in evaluating a patient's acid-base balance, ventilation, and oxygenation. The insights gained allow Veterinary professionals to plan targeted therapeutic interventions, ensuring timely care for critically ill animals.

When to Use Blood Gas Analysis

Blood gas testing is particularly beneficial in identifying hidden disease processes and assessing their severity. This information guides interventions such as administering intravenous fluids, providing oxygen therapy, supplementing electrolytes, and adjusting mechanical ventilation. Arterial blood gas (ABG) analysis helps measure how well oxygen is absorbed into the bloodstream from the lungs and how efficiently carbon dioxide (CO_2) is expelled. Venous blood gas (VBG) analysis focuses primarily on the acid-base status and ventilation indicators, including venous CO_2 levels ($PvCO_2$). In well-perfused patients, $PvCO_2$ values are typically 4 to 6 mmHg higher than arterial CO_2 levels ($PaCO_2$). However, the gap can widen with reduced blood perfusion, indicating systemic stress.

Key Parameters and their Role

Portable analyzers measure essential parameters like pH, PaO_2 (oxygen pressure in arterial blood), and $PaCO_2$ (carbon dioxide pressure). These values are used to derive bicarbonate concentration (HCO_3^-), total CO_2 (TCO_2), oxygen saturation (SO_2), and the base excess in extracellular fluid (BEecf). Each of these parameters plays a role in understanding both metabolic and respiratory conditions.

For example, the bicarbonate concentration and BEecf reflect metabolic function, whereas CO_2 pressure reflects ventilation efficiency. Oxygenation is primarily evaluated through PaO_2 levels, which can indicate the adequacy of pulmonary gas exchange. Analyzers also generate oxygen saturation percentages using the oxygen dissociation curve, providing a clearer picture of how well hemoglobin is loaded with oxygen.

Indications for Blood Gas Analysis

Blood gas tests are recommended in various clinical scenarios:

- **Respiratory distress**: Helps identify if hypoventilation or lung pathology is causing respiratory acidosis.
- **Shock or sepsis**: Determines acid-base disturbances caused by metabolic issues, such as lactic acidosis.
- **Post-operative monitoring**: Ensures the stability of ventilation and oxygen levels.
- **Trauma and dehydration**: Detects metabolic acidosis caused by impaired perfusion.

Arterial samples are typically collected from accessible arteries like the femoral or dorsal pedal artery, especially in emergencies or anesthesia. Venous samples are more convenient in less critical situations and can offer complementary information

Step-by-Step Approach to Blood Gas Analysis

1. Assess pH Levels

Blood pH measures the body's overall acid-base balance, with neutral levels being around 7.4. Acidosis refers to pH values below 7.35, while alkalosis occurs when pH rises above 7.45. The balance between bicarbonate and CO_2 regulates this value. The Henderson-Hasselbalch equation expresses the relationship between these two elements:

pH=log([HCO3−]0.03×PCO2)pH = \log\left(\frac{[HCO_3^-]}{0.03 \times PCO_2}\right)pH=log(0.03×PCO2[HCO3−])

Acidic or alkaline changes in pH generally align with the primary disorder (metabolic or respiratory).

2. Examine the Respiratory Component

$PaCO_2$ values assess the respiratory function by measuring how effectively CO_2 is expelled. If $PaCO_2$ levels exceed 45 mmHg, this suggests hypoventilation and respiratory acidosis. Hypoventilation can result from sedation, airway obstructions, or neuromuscular issues, preventing adequate CO_2 clearance. Conversely, $PaCO_2$ values below 35 mmHg indicate hyperventilation, which may cause respiratory alkalosis. This condition can arise from pain, anxiety, or pulmonary issues that drive rapid breathing.

3. Evaluate the Metabolic Component

Metabolic conditions affect blood bicarbonate levels and BEecf. Low bicarbonate or BEecf values indicate metabolic acidosis, whereas elevated levels signal metabolic alkalosis. The normal bicarbonate range for dogs is 19–23 mEq/L, and for cats, it is 17–21 mEq/L. Imbalances may occur due to increased acid production (e.g., lactate buildup or ketones) or bicarbonate loss through diarrhea or renal dysfunction.

BEecf helps quantify the metabolic contribution to acid-base balance, accounting for the buffering effect of bicarbonate. This parameter predicts the amount of acid or base needed to restore pH to normal (7.4) under standardized CO_2 levels. A BEecf lower than -4 mEq/L indicates metabolic acidosis, while values above +4 suggest metabolic alkalosis.

4. Assess Compensatory Responses

The body attempts to correct acid-base disturbances through compensatory mechanisms. For example, metabolic acidosis leads to increased respiration to expel CO_2 and restore pH balance. Table 1 summarizes the primary acid-base disorders and their corresponding compensatory responses. While compensation never fully normalizes pH, it reduces deviations toward neutrality.

Mixed acid-base disorders occur when the compensatory mechanisms fail to align with expected values. For instance, inadequate respiratory compensation for metabolic acidosis may indicate an additional respiratory disorder. In contrast, proper compensation would show proportional changes between CO_2 and bicarbonate levels.

5. Monitor Oxygenation Status

Oxygenation is assessed through PaO_2 levels, with hypoxemia defined as PaO_2 values below 80 mmHg. Critical levels below 60 mmHg demand immediate intervention. When patients present with low oxygen levels, the alveolar-arterial (A-a) oxygen gradient helps determine if the issue lies in pulmonary function. Normal A-a gradients are between 5 and 15 mmHg. An elevated gradient signals potential ventilation-perfusion mismatches, which impair gas exchange efficiency. Oxygen therapy can correct most hypoxemia cases, though mechanical ventilation may be needed if alveoli remain collapsed.

Interpreting Blood Gas Data in Clinical Practice

The Four Primary Acid-Base Disorders

1. Metabolic Acidosis:
- **Causes**: Renal failure, dehydration, diabetic ketoacidosis.
- **Symptoms**: Low pH, low bicarbonate, compensatory hyperventilation.

2. Metabolic Alkalosis:
- **Causes**: Vomiting, diuretics, sodium bicarbonate therapy.
- **Symptoms**: High pH, high bicarbonate, hypoventilation to retain CO_2.

3. Respiratory Acidosis:
- **Causes**: Anesthesia, airway obstruction, lung disease.
- **Symptoms**: Low pH, high $PaCO_2$.

4. Respiratory Alkalosis:
- **Causes**: Pain, anxiety, high altitude.
- **Symptoms**: High pH, low $PaCO_2$.

Compensatory Mechanisms in Acid-Base Disorders
- **Metabolic Compensation:**
  - o. In respiratory acidosis, kidneys retain bicarbonate to raise pH.
  - o. In respiratory alkalosis, kidneys excrete bicarbonate to lower pH.
- **Respiratory Compensation:**
  - o. In metabolic acidosis, hyperventilation expels CO_2 to restore pH.
  - o In metabolic alkalosis, hypoventilation retains CO_2.

Mixed Acid-Base Disorders
- **Definition:** Occurs when two primary disorders coexist (e.g., metabolic acidosis with respiratory alkalosis).
- **Clinical Example:**
  - o. A patient with kidney failure and hyperventilation shows metabolic acidosis with respiratory alkalosis.
- **Challenges in Diagnosis:**
  - o. Requires comparing actual CO_2 and bicarbonate levels with expected compensatory changes.
  - o. Identifying mixed disorders is crucial for effective treatment.

Treatment of Acid-Base Disorders

Metabolic Acidosis:

Metabolic acidosis occurs due to an accumulation of acids or a loss of bicarbonate. This condition is categorized into two main types:

1. Increased Anion Gap Acidosis (Normochloremic)

Causes**:**

- Lactate accumulation from hypovolemia or hypoxia
- Diabetic ketoacidosis (presence of ketones)
- Uremia (buildup of uremic acids like sulfates and phosphates)
- Toxins (ethylene glycol or salicylates)

2. Normal Anion Gap Acidosis (Hyperchloremic)

Causes

- Renal tubular acidosis
- Bicarbonate loss through diarrhea

Clinical Signs and Treatment

Metabolic acidosis can result in hypotension, arrhythmias, insulin resistance, and mental dullness. Treatment focuses on correcting the underlying cause. **Fluid resuscitation** is key in hypovolemia induced lactic acidosis. Severe, persistent cases may require **sodium bicarbonate administration**, particularly if fluid therapy alone does not restore normal pH levels.

Metabolic Alkalosis:

Metabolic alkalosis is characterized by an excessive loss of hydrogen ions or increased bicarbonate. Common causes include **upper gastrointestinal obstruction** leading to loss of H^+ and Cl^- through vomiting and excessive use of diuretics (like furosemide).

Clinical Signs and Treatment

Patients exhibit neuromuscular dysfunction, hypokalemia, and potentially cardiac arrhythmias. Treatment involves addressing the underlying cause, correcting volume depletion using **sodium chloride infusion**, and supplementing potassium if necessary. If alkalosis is caused by diuretic use, discontinuing the diuretic or adjusting the dose can be effective.

Respiratory Acidosis and Alkalosis

1.Respiratory Acidosis

Caused by **hypoventilation**, which leads to an accumulation of CO_2 and decreased pH.

- **Etiology**: Airway obstruction, neurological disorders, neuromuscular diseases, pulmonary diseases like pneumonia
- **Treatment**: Ensure adequate ventilation through positive pressure support or endotracheal intubation. If drug-induced, reversal agents should be administered promptly

2.Respiratory Alkalosis

Resulting from **hyperventilation**, this condition leads to a reduction in CO_2 levels and increased pH.

- **Causes**: Stress, pain, hypoxemia, central nervous system disturbances, excessive mechanical ventilation
- **Treatment**: Managing the root cause—oxygen supplementation for hypoxia, analgesia for pain, or reducing ventilation rates—often resolves the issue.

Case Studies

1.Case of Respiratory Acidosis:

A dog under anesthesia shows $PaCO_2$ of 60 mmHg and pH of 7.25, indicating hypoventilation. Increasing ventilation rates corrected the imbalance.

2.Case of Metabolic Acidosis:

A cat with kidney failure presents with a pH of 7.1 and low bicarbonate levels. Intravenous fluids improved hydration and corrected the acid-base disturbance.

3. Mixed Acid-Base Disorder:

A trauma patient exhibits both respiratory acidosis ($PaCO_2$ = 55 mmHg) and metabolic acidosis (HCO_3^- = 10 mEq/L). Treatment involved both oxygen support and fluids.

4. GI Obstruction in a Boxer

A 4-year-old Boxer exhibited metabolic alkalosis due to **chloride and potassium loss through vomiting.** Radiographs identified a gastrointestinal obstruction. Following fluid resuscitation, an exploratory laparotomy was performed, removing the obstruction and normalizing the dog's acid base balance.

Conclusion

Acid-base imbalances are complex disorders requiring thorough diagnostic evaluation through blood gas analysis and electrolyte monitoring. Timely identification of the primary disorder and appropriate intervention are crucial to prevent life-threatening complications. Fluid therapy, ventilation support, and electrolyte replacement are essential components of the treatment strategy. Understanding acid-base physiology allows clinicians to provide better care for critically ill animals, ensuring favourable outcomes.


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