• V – Vascular
• I – Infectious / Inflammatory
• T – Trauma
• A – Anomalous
• M – Metabolic
• I – Idiopathic
• N – Neoplasia
• D – Degenerative
Anomalous

- Vertebral malformations
- Cysts / Diverticula
- Cervical spondylomyelopathy (Wobbler)
Vertebral Malformations

• Variety of neurologic symptoms
  ▪ Myelopathy
  ▪ Radiculopathy

• However...
  ▪ VAST majority are incidental findings / clinically insignificant
Vertebral Malformations

• Generally breed-associated
• Exception
  ▪ Mucolipidosis
• Bulldog overrepresented
  ▪ Also...
Vertebral Malformations

- Many different classification systems
  - Stage of development
    - Embryonic
      - Hemivertebrae
      - Wedge vertebrae
      - Butterfly vertebrae
    - Fetal
      - Block vertebrae
      - Articular process hypoplasia
Vertebral Malformations

- Partial unilateral failure of formation (wedge vertebrae)
- Complete unilateral failure of formation (hemivertebra)
- Unilateral failure of segmentation (congenital bar)
- Bilateral failure of segmentation (block vertebra)

Articular Process Hypoplasia

- Hypoplasia or aplasia
- Pugs
Articular Process Hypoplasia

• “Pug Myelopathy”
• Hypoplasia / aplasia of caudal articular facets
  ▪ Thoracolumbar region
• Leads to chronic instability and secondary fibrous band
  ▪ → Constrictive myelopathy

Vertebral Malformations

- Diagnostics
  - Radiography
    - Most are easily identified
  - MRI
    - Cross-sectional analysis
    - Spinal cord compression
    - Other abnormalities
      - Disc
      - Cyst / diverticula
Vertebral Malformations

• Treatment
  ▪ Dependent on...
    • Significance
    • Type
    • Number
    • Severity
    • Stability
Vertebral Malformations

• Treatment
  - Medical management
    • Strict confinement
    • NSAIDs vs. steroids
    • Analgesic therapy
  - Surgery
    • Rarely performed...
Vertebral Malformations

• Surgical Management
  ▪ More common to address secondary disease
    • Block vertebrae
      – Disc
    • Hemivertebrae
      – Cyst / diverticula
Vertebral Malformations

• Surgical Management
  ▪ Simple
    • Dorsal laminectomy
    • Hemilaminectomy
  ▪ Complex
    • Requiring stabilization
“Chewy”

- 4 month old Chihuahua mix
- Weak / wobbly in PL since adoption
“Chewy” MRI
“Chewy”
“Chewy”
Post-op radiographs

Right lateral

VD
Vertebral Malformations

- The 4 Questions
  - **Onset?**
    - Chronic
      - Months to years
  - **Progression?**
    - Slowly progressive
  - **Symmetry?**
    - Usually symmetric
  - **Painful?**
    - No

The only disability in life is a bad attitude.
Spinal Arachnoid Diverticula

• Focal dilations of the subarachnoid space
• Formerly known as cysts
• More common in brain

https://www.researchgate.net/figure/262810151_fig2_Transverse-plane-CT-myelogram-CT-image-showing-the-focalaccumulation-of-contrast-medium
Spinal Arachnoid Diverticula

- Compressive myelopathy
- Most common symptom
  - Proprioceptive ataxia
- Two groups of dogs
  - Cervical
    - Large breed dogs
      - Rottweiler
  - **Thoracolumbar***
    - Frenchies and Pugs
Spinal Arachnoid Diverticula

- Corkscrew tail breeds
- Very common to have concurrent disease adjacent to SAD
Spinal Arachnoid Diverticula

• Diagnostics
  ▪ CT / myelogram?
  ▪ MRI!!

• Diagnosis
  – FLAIR

• Also...
  – Cord changes
    » Edema, gliosis
  – Concurrent diseases
“Francisco”
“Francisco”
Spinal Arachnoid Diverticula

• Treatment
  ▪ Medical management
    • Prednisone (low dose)
    • Omeprazole
    • +/- furosemide, acetazolamide
  ▪ Surgery
    • Laminectomy
    • Durotomy
    • Marsupialization
Spinal Arachnoid Diverticula

- Prognosis
  - Medical therapy
    - Unknown – no studies to date
    - “Guarded”
  - Surgery
    - ~63% - improved
    - ~37% - worsened
Spinal Arachnoid Diverticula

• The 4 Questions
  ▪ Onset?
    • Chronic
      – Months to years
  ▪ Progression?
    • Slowly progressive
  ▪ Symmetry?
    • Usually symmetric
  ▪ Painful?
    • No
Cervical Spondylomyelopathy

• “Wobbler syndrome”
• Condition of large and giant breed dogs
• Static or dynamic compression
  ▪ Spinal cord
  ▪ Nerve roots
  ▪ → pain and spinal cord dysfunction
• Causes
  ▪ Genetic, congenital, conformational, nutritional
Cervical Spondylomyelopathy

• Breeds
  ▪ Great Dane, Doberman, Basset

• Pathogenesis
  ▪ Multifactorial
  ▪ Canal stenosis from disc, ligament, joint capsule, bone, vertebral instability, among others...
Cervical Spondylomyelopathy

- Two forms
  - Doberman
    - Older dogs (6.8 years)
    - Caudal cervical
    - Disc-associated
  - Great Dane
    - Younger dogs (3.8 years)
    - Cranial-to-mid cervical
    - Osseous-associated
Cervical Spondylomyelopathy

- Basset hound
  - Unique form of disease
  - JVIM, 2012, De Decker et. Al
  - Dorsal lamina & spinous process hypertrophy
  - → leads to ligamentum flavum hypertrophy
Basset Spondylomyelopathy
Basset Spondylomyelopathy
“George” – 5 mo Basset Hound
Cervical Spondylomyelopathy

• Diagnostics
  ▪ CT / Myelography
  ▪ MRI
    • Diagnosis
    • Dynamic vs. static
    • Cord changes***
“Fitz” – 2 yo MN Great Dane
Cervical Spondylomyelopathy

• Treatment

- Medical
  - Prednisone
  - Gabapentin
  - Controlled exercise

- Surgery
  - Dependent on type, extent, severity
  - Ventral slot, dorsal laminectomy
  - +/- stabilization
  - Disc replacement??

Cervical Spondylomyelopathy

• The 4 Questions
  ▪ Onset?
    • Chronic, Acute-on-Chronic
  ▪ Progression?
    • Progressive
  ▪ Symmetry?
    • Usually symmetric
  ▪ Painful?
    • Osseous-associated
      – 50/50
    • Disc-associated
      – Yes!
• V – Vascular
• I – Infectious / Inflammatory
• T – Trauma
• A – Anomalous
• M – Metabolic
• I – Idiopathic
• N – Neoplasia
• D – Degenerative
Neoplasia

- Primary
  - Arising from the spinal cord or meninges
- Secondary
  - Adjacent
Primary SC Neoplasia

- Can be broken into 2 categories
  - Intramedullary
  - Intradural, extramedullary

http://sevneurology.com/lupa-spinal-tumor/
Intramedullary SC Neoplasia

- Uncommon
  - ~15% of spinal cord tumors
- 2/3 are primary
  - Neuroepithelial
    - Glial cells
    - Ependyma
- 1/3 are secondary
  - Metastatic
Intramedullary SC Neoplasia

- **Primary tumors**
  - More common...
    - Young dogs
    - Cervical spinal cord
- **Secondary**
  - More common...
    - Older dogs
    - Thoracolumbar spinal cord
Intramedullary SC Neoplasia

• Primary tumors
  ▪ Mean age is 5.9 years
  ▪ Most common is ependymoma
    • Followed by
      – Astrocytoma
      – Oligodendroglioma
Intramedullary SC Neoplasia

- Secondary / metastatic tumors
  - Mean age is 10.8 years
  - Most common...
    - Hemangiosarcoma
    - TCC
    - Prostatic carcinoma
    - LSA?
Intramedullary Neoplasia

• The 4 Questions
  ▪ Onset?
    • Acute-to-chronic
  ▪ Progression?
    • Progressive
  ▪ Symmetry?
    • Often symmetric
  ▪ Painful?
    • Nope!!
Intradural, Extramedullary

A: Normal
B: Intramedullary
C: Intradural-extramedullary
D: Extradural

Intradural, Extramedullary

• Meningioma
  - Most common in dogs
  - Arises from arachnoid granulation of meninges
    - Locations
      - Cervical most common
  - Grades
    - I-III
  - Types
    - Numerous!!
Meningothelial Meningioma

Microcystic Meningioma

Meningioma

• Treatment
  ▪ Palliative care
  ▪ Oral chemotherapy
    • Hydroxyurea
  ▪ Surgery alone
    • 1410-1440 days (Levy et. al 1997)
    • 19 months (Petersen et. al 2008)
  ▪ Surgery + Radiation
    • ??? Likely longer…
Intradural, Extramedullary

• Nerve sheath tumors
  ▪ Types
    • Schwannomas
    • Neurofibromas
    • Neurofibrosarcomas
Nerve Sheath Tumors
Nerve Sheath Tumors

• Treatment
  ▪ Palliative care
  ▪ Radiation
    • 371 ± 30 days
  ▪ Surgery alone
    • 6-9 months
  ▪ Surgery + Radiation
    • ??? Likely longer...
Nephroblastoma

• “Thoracolumbar tumor of young dogs”
• Embryonal tumors of the kidneys
• Neoplastic transformation of blastemal cells
  ▪ Retroperitoneal → primary renal tumor
  ▪ Within dura → spinal tumor
• T10-L3
• GSD, Golden retrievers
Nephroblastoma

• Age at onset
  ▪ 5-48 months
    • Median 14 months
  ▪ Progressive symptoms
    ▪ T3-L3
    ▪ Paraparesis / ataxia to paraplegia
Nephroblastoma
Nephroblastoma

• **Treatment**
  - Medical management
  - Surgery
    - Dorsal / hemilaminectomy
    - Durotomy

• **Prognosis**
  - Poor
    - MST 30 days in all dogs
    - Surgical resection
      - MST 70.5 days
Extradural Tumors

- Vertebral tumors
  - Osteosarcoma
  - Fibrosarcoma
  - Chondrosarcoma
  - Multiple myeloma
  - Lymphoma
  - Metastatic...
Extradural Tumors

• Other sites
  ▪ Soft tissue
  ▪ Abdominal
  ▪ Retroperitoneal
  ▪ Esophageal
ID-EM and Extradural Tumors

- The 4 Questions
  - Onset?
    - Acute-to-chronic
  - Progression?
    - Progressive
  - Symmetry?
    - ED $\rightarrow$ Symmetric
    - ID-EM $\rightarrow$ Asymmetric
  - Painful?
    - Most are...
      - Meninges, nerve, muscle
• V – Vascular
• I – Infectious / Inflammatory
• T – Trauma
• A – Anomalous
• M – Metabolic
• I – Idiopathic
• N – Neoplasia
• D – Degenerative
Degenerative

- Intervertebral disc disease (IVDD)
- Degenerative myelopathy (DM)
Max,
7 yr, MN Dachshund
Max – The Situation

• 2 days ago – sudden onset not walking, painful
• 1 day ago – pcDVM - paralyzed and no deep pain
• Your exam – quite the same

• Diagnosis? Prognosis?
Max – The truth

- Came in through ER (~8PM)
  - Plegic, DPP (NEGATIVE)
- Advised to wait til AM to have MRI

- 8AM
  - Exam unchanged.
Outcome

• Left hemilaminectomy at T12-T13 with removal of massive amount of paste-like disc

• Grossly normal spinal cord

• Weakly ambulatory at discharge 2 ½ days later
<table>
<thead>
<tr>
<th>Deep Pain Negative &amp; Hemilaminectomy</th>
<th>Deep Pain Positive &amp; Hemilaminectomy</th>
</tr>
</thead>
<tbody>
<tr>
<td>T2 Signal Changes</td>
<td>T2 Signal Changes</td>
</tr>
<tr>
<td>Number Recovered</td>
<td>Number Recovered</td>
</tr>
<tr>
<td>Success Rate</td>
<td>Success Rate</td>
</tr>
<tr>
<td>None noted</td>
<td>None noted</td>
</tr>
<tr>
<td>13/13</td>
<td>31/31</td>
</tr>
<tr>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>&lt; 3x length L2</td>
<td>&lt; 3x length L2</td>
</tr>
<tr>
<td>4/6</td>
<td>11/12</td>
</tr>
<tr>
<td>66%</td>
<td>92%</td>
</tr>
<tr>
<td>&gt; 3 x length L2</td>
<td>&gt; 3 x length L2</td>
</tr>
<tr>
<td>1/10</td>
<td>2/5</td>
</tr>
<tr>
<td>10%</td>
<td>40%</td>
</tr>
<tr>
<td>Totals</td>
<td>Totals</td>
</tr>
<tr>
<td>18/29</td>
<td>44/48</td>
</tr>
<tr>
<td>62%</td>
<td>92%</td>
</tr>
</tbody>
</table>

- MRI findings best predictor of outcome in paraplegic dogs
- Generally success rates are 92% and 62%, in DPP+, DPP – respectively

MRI as predictor of outcome

• Allows for evaluation of SC health

• Without MRI
  ▪ Prognoses range from 10-100%
    • “50/50”

• MRI allows for...
  ▪ Establishment of diagnosis
  ▪ Accurate prognosis!
Why wait??

- Our beliefs
  - Diagnostic and prognostic value of MRI is worth the wait
  - CT / myelogram??
  - Little harm in waiting

- 2 components of injury caused by disc rupture
  - 1) Concussive internal injury sustained at moment of impact
    - Most important / fate is sealed at time of rupture
  - 2) Ongoing compression
Why MRI for Type I Disc Disease?

- MRI consistently superior to myelography for determining lesion localization and lateralization (Bos)

- Correlation between MRI and surgical findings is 100% for lesion localization and lateralization (Besalti, Naude)

- Superior to deep pain status in determining outcome in paraplegic dogs

Bos AS. University of Guelph. 2008: 113-49  
No harm in waiting...

- JAVMA 2016
  - Jeffery et. al
- Goals of study
  - Identify factors associated with recovery of locomotion
- 78 dogs that underwent spinal surgery for IVDD
  - Iowa State, TAMU, UK
• Results
  ■ No evidence that prognosis for recovery of ambulation was related to time from onset of non-ambulatory state or loss of DPP

• Conclusion
  ■ “Immediacy of surgical treatment had no apparent association with outcome”
  ■ Rather, the prognosis strongly influenced by nature of initiating injury
Further Evidence...

- **JAVMA 2003**
  - *Olby et. al*
  - Study on spinal trauma
    - Including IVDD, HBC, etc.
  - Outcome was not associated with duration of paraplegia
  - Additionally, 0% of DPP(-) dogs recovered that had suffered “trauma” (fracture, subluxation, etc.)
Further Evidence...

• JSAP 1999
  ▪ Scott, McKee
  ▪ No statistical significance to show duration of loss of DPP impacted the prognosis

• JAVMA 2005
  ▪ Ito et. al
  ▪ Duration of clinical signs
    • Not associated with outcome
However….

• We do still recommend prompt establishment of diagnosis and prognosis
• Surgical intervention (if indicated)
  ▪ Sooner rather than later.
Type I Disc Disease
Intervertebral Disc Degeneration

Type I - Breeds

• Overall prevalence = 2% (Bray, 1998)
• Dachshunds (20%), Pekingese, beagle, cocker
Type I – Age

- Chondrodystrophic: 3-7 years
- Non-chondrodystrophic: 6-8 years
  - Large breed dogs: mixed, German Shepherd, Labrador, Rottweiler, Dalmatian, Doberman
Surgery vs. Medical Management?

- In general with an isolated disc rupture...
  - **Surgery**
    - Prognosis with surgery is >95%
    - Quicker recovery
    - Low recurrence with fenestration
      - ~8%
  - **Medical management**
    - Fair prognosis
    - Recurrence rates
      - 30-50%
• What are we trying to accomplish?
• Rest is key!!!!
  ▪ All medically managed cases will be more likely to fail if not rested.
• So, rest (not medication) is more important!
NSAIDS > Steroids

- NSAID therapy associated with higher satisfaction (better pain control, fewer side effects) via questionnaire (Levine)
- Administration of steroid is associated with higher rate of GI and urinary complications causing increased hospital stay
- NSAIDS lower recurrence rate than prednisone (Mann)
- Steroids impair healing (annulus)

Medical

• My preference
  - NSAID
    • Meloxicam, Carprofen
  - Gabapentin
  - Tramadol
  - Muscle relaxer

• Other
  - Urinary status
Surgery

• Best if done sooner...
• If delayed
  ■ >2 weeks
  ■ Prognosis could worsen
  ■ Why?
  • Disc material analogy
  • If delayed...
    – Adhered to dura, vessels
    – More challenging
    – More dangerous
Type 1 Disc Summary

- Not as time sensitive as once thought.
  - Down ≠ Down n’ Out
- Recommend referral in all dogs with suspected disc disease
  - Establish diagnosis and PROGNOSIS
- Educate owners of risks associated with medical management
  - Recurrence
  - Surgery for chronic discs
Type 1 Disc

• The 4 Questions
  ▪ Onset?
    • Peracute-to-acute
  ▪ Progression?
    • Progressive
  ▪ Symmetry?
    • Often subtly asymmetric
  ▪ Painful?
    • Yes!
Disc Disease – Type 2

• Signalment
  - Large breed dogs
  - 6-8 years
  - GSD, Lab, Golden
Disease Physiology

- Disc degeneration
- Fibrous form of metaplasia
  - nucleus pulposus replaced with fibrocartilage
  - weakening of the dorsal annulus
  - protrusion, bulging of annulus
Type 2 - Signs / Progression

• Lumbosacral (L7-S1) disc protrusions
  • Slow to rise / sit
  • Paraparesis
  • Poor reflexes
  • Incontinence
  • Tail abnormalities
  • Pain

• Low cervical disc protrusions (Disc associated Wobbler’s syndrome or DAWS)
  • Tetraparesis
  • Tetra-ataxia
  • Pain
Surgery and L7-S1 Type II Disc

- Dorsal laminectomy with fenestration
- 131 cases, GSD, painful / reluctant to jump, rise, climb
  - 93% improved, 17% recurrence rate (Danielsson)
- 69 cases, various grades, 78% good outcome (De Risio)

Urinary or fecal incontinence has a worse prognosis
Chronic urinary incontinence predicts poor outcome

DO NOT confuse with orthopedic disease and wait to address the problem until incontinent

Type 2 Disc

• The 4 Questions
  ▪ Onset?
    • Chronic
  ▪ Progression?
    • Progressive
  ▪ Symmetry?
    • Usually symmetric
  ▪ Painful?
    • Yes
IVDD in Cats??

- Yes!
- Far less common
- Older
- Lumbar disc disease
  - L4-L5
- Type 1 > Type 2
- Outcome similar to dogs
“Amy” – 11 yo FS Balinese
Degenerative Myelopathy

- First described in 1973
  - Non-specific degeneration
- Most dogs in initial reports were GSD
- However, common in several other breeds
  - Overall prevalence of 0.19%
Degenerative Myelopathy

• Cause
  ▪ Mutation in superoxide dismutase 1 gene
    • SOD1
    • Antioxidant / free radical scavenger
  ▪ Amyotrophic lateral sclerosis
    • ALS / Lou Gehrig’s disease
    • Differences
      – Neuron vs. axon
Degenerative Myelopathy

- Progressive disease in older dogs
  - 8-14 years
- Large breed dogs
  - GSD, Boxer, CBR
  - Mean age of 9 yo
- PWC
  - Mean age of 11 yo.
Degenerative Myelopathy

• Clinical Progression
  ▪ Spectrum of symptoms
    • Proprioceptive ataxia, paraparesis
      – T3-L3 spinal cord segments
    • Progress to non-ambulatory state (6-20 months)
      – LMN paraplegia
      – → tetraplegia
      – → brainstem signs
Degenerative Myelopathy

• Antemortem Diagnostics
  ▪ MRI
    • Diagnosis of exclusion / presumptive diagnosis
      – Normal MRI
      – Cord atrophy
  ▪ CSF
    • Normal
    • High protein
Degenerative Myelopathy

• Genetic test
  ▪ Mizzou
  ▪ OFA

• Samples
  ▪ Cheek swab
  ▪ Whole blood

• Results

G/G – Normal
A/G – Carrier
A/A – Affected
Degenerative Myelopathy

• Treatment?
  ▪ No definitive treatment
  ▪ Supportive care
    • Exercise/physical therapy
    • Vitamin supplementation?
  ▪ Good nutrition
  ▪ Weight control
Degenerative Myelopathy

- The 4 Questions
  - Onset?
    - Chronic!
  - Progression?
    - Progressive
  - Symmetry?
    - Often symmetric
  - Painful?
    - No.
Take Home Points

• MRI is the best diagnostic modality to evaluate spinal cord health, determine an accurate prognosis and to plan appropriate therapy
• Not everything is a disc!!!
References

- Dolera M\textsuperscript{1}, Malfassi L\textsuperscript{1}, Bianchi C\textsuperscript{1}, Carrara N\textsuperscript{1}, Finesso S\textsuperscript{1}, Marcarini S\textsuperscript{1}, Mazza G\textsuperscript{1}, Pavesi S\textsuperscript{1}, Sala M\textsuperscript{1}, Urso G\textsuperscript{1,2}. Frameless stereotactic volumetric modulated arc radiotherapy of brachial plexus tumours in dogs: 10 cases. \textit{Br J Radiol.} 2017 Jan;90(1069).
References


Any Questions??