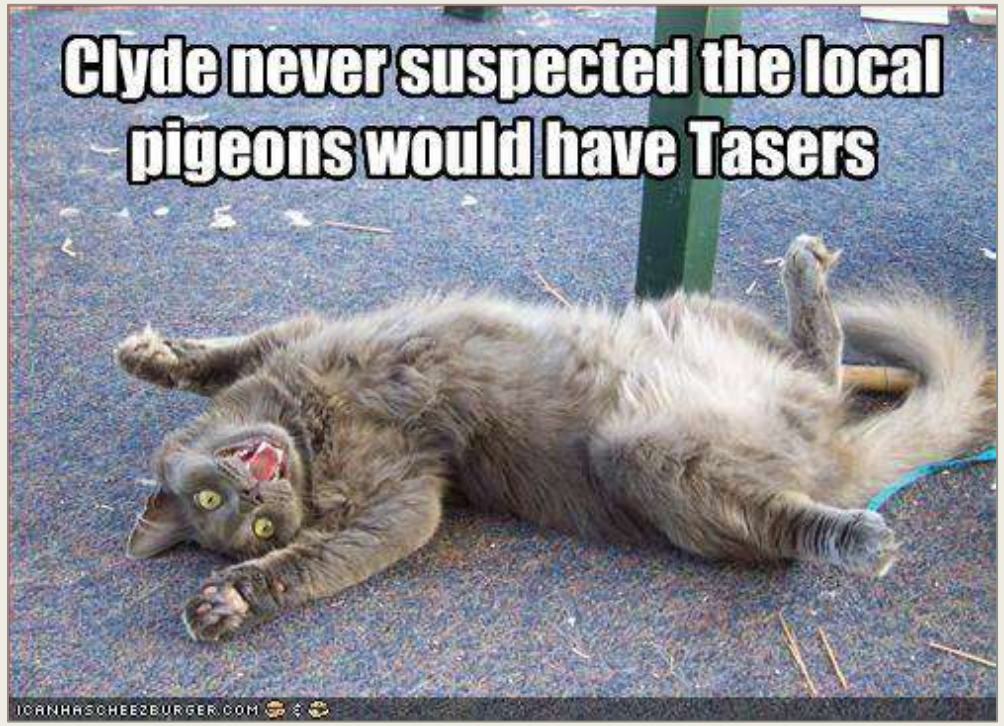
ASSESSING NEUROLOGIC TRAUMA

Erica A. Miller, DVM

Plan

- CNS Injury: what & how
  - *Anatomy*
- Neuro Exam
- Triage/Prognosis
- Treatments
- Pre-Release Evaluation



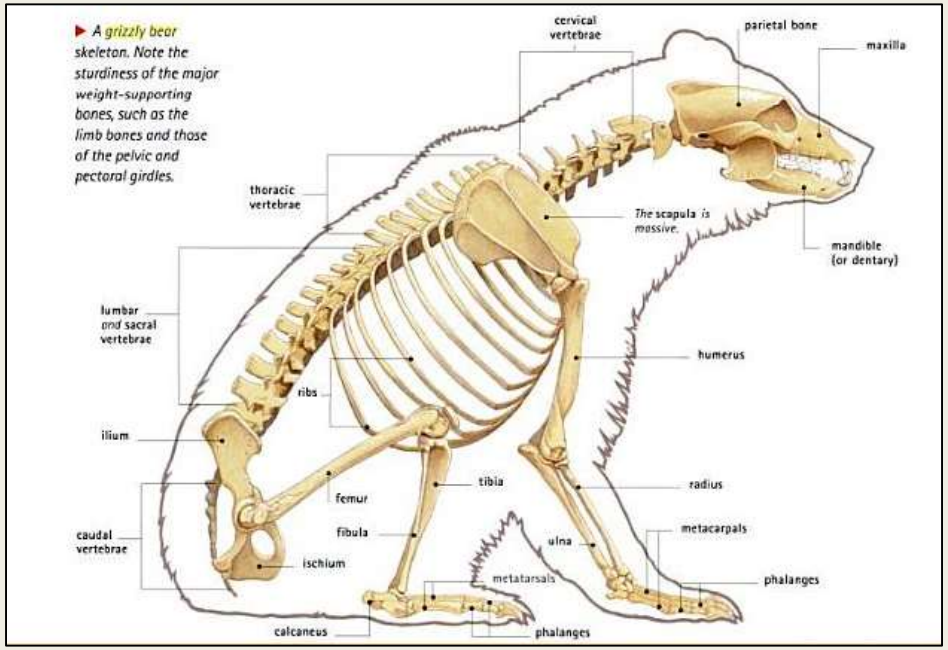
CNS Injury in Trauma Patients--**What**

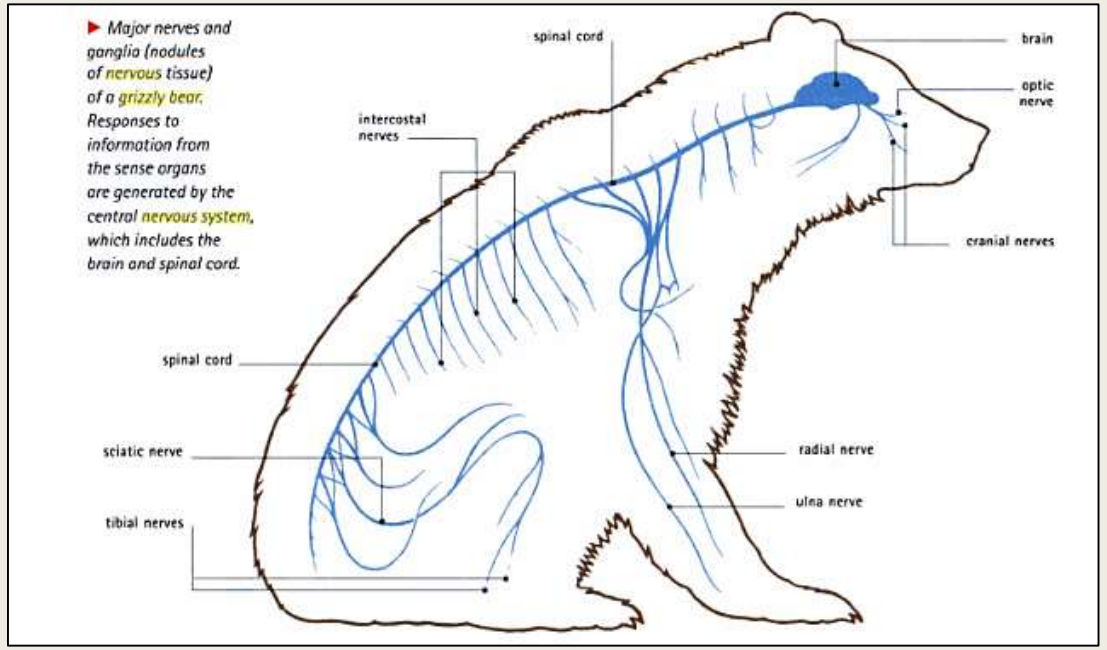
- Brain Trauma
- Spinal Trauma

- Head Trauma

  = Brain +/- Spinal injury

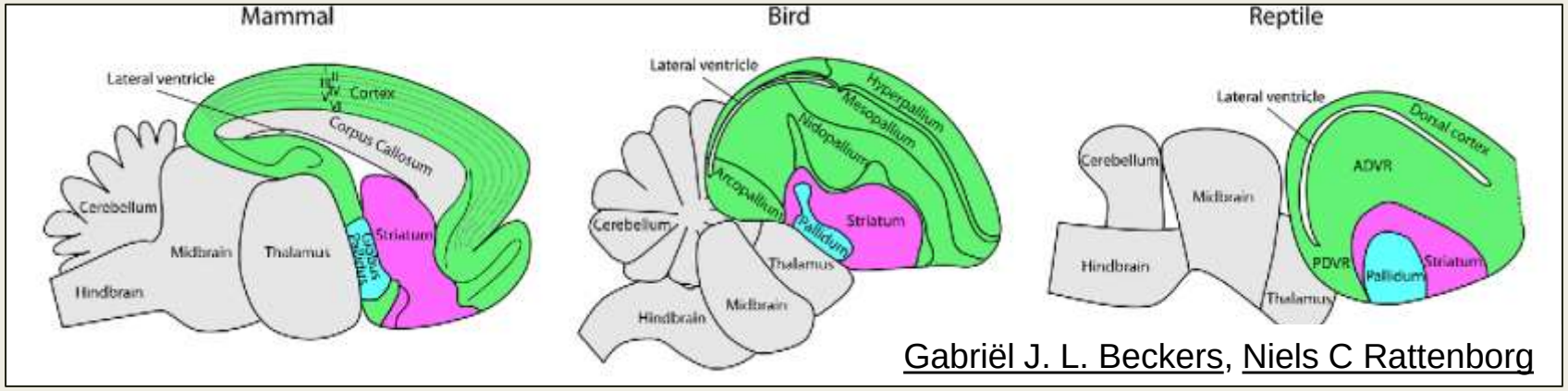
CNS Anatomy: located within the skull & spine
--PNS parallels the skeleton in soft tissue





General Brain Anatomy

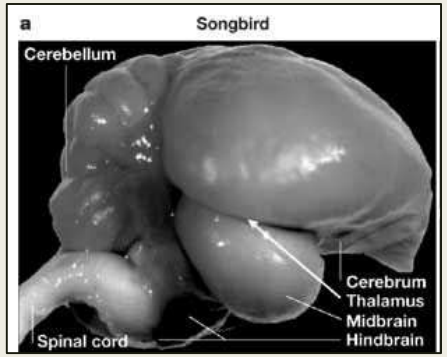
- Hindbrain: brainstem = arousal & basic functions (breathing)
- Midbrain: integrates signals from eyes & ears with muscle movement
- Forebrain: cortex= analyze sensory info



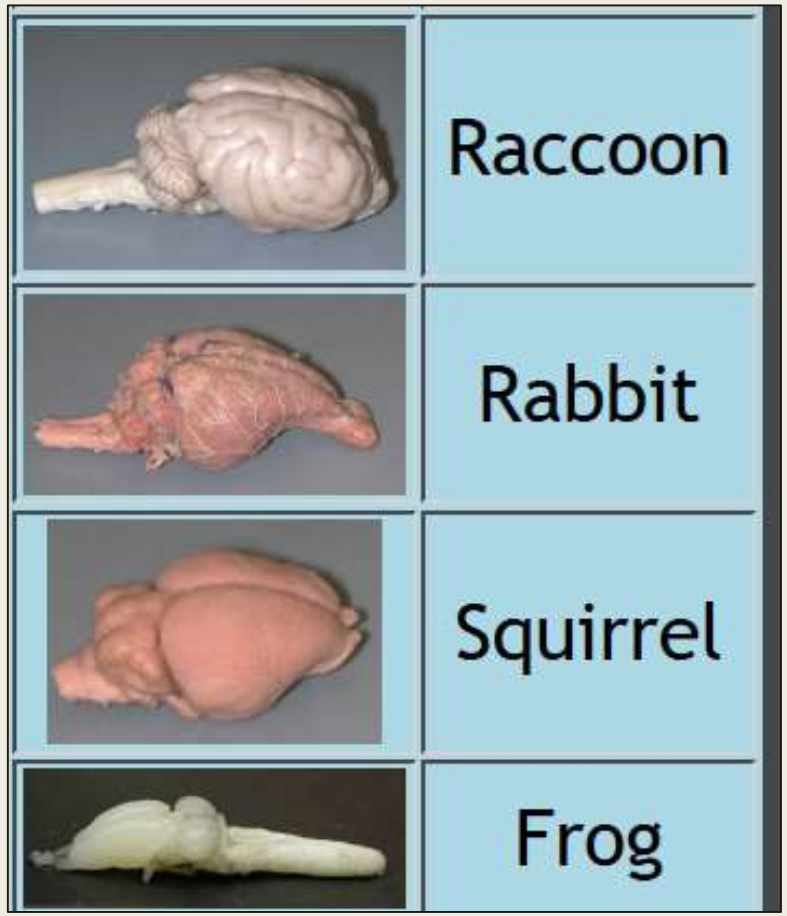
Gabriël J. L. Beckers, Niels C Rattenborg

Diversity

- Hindbrain = life functions
  - *Cerebellum = balance*
- Midbrain = ears & eyes
- Cortex = ‘thought’, sensory info



www.nature.com/articles/nrn1606

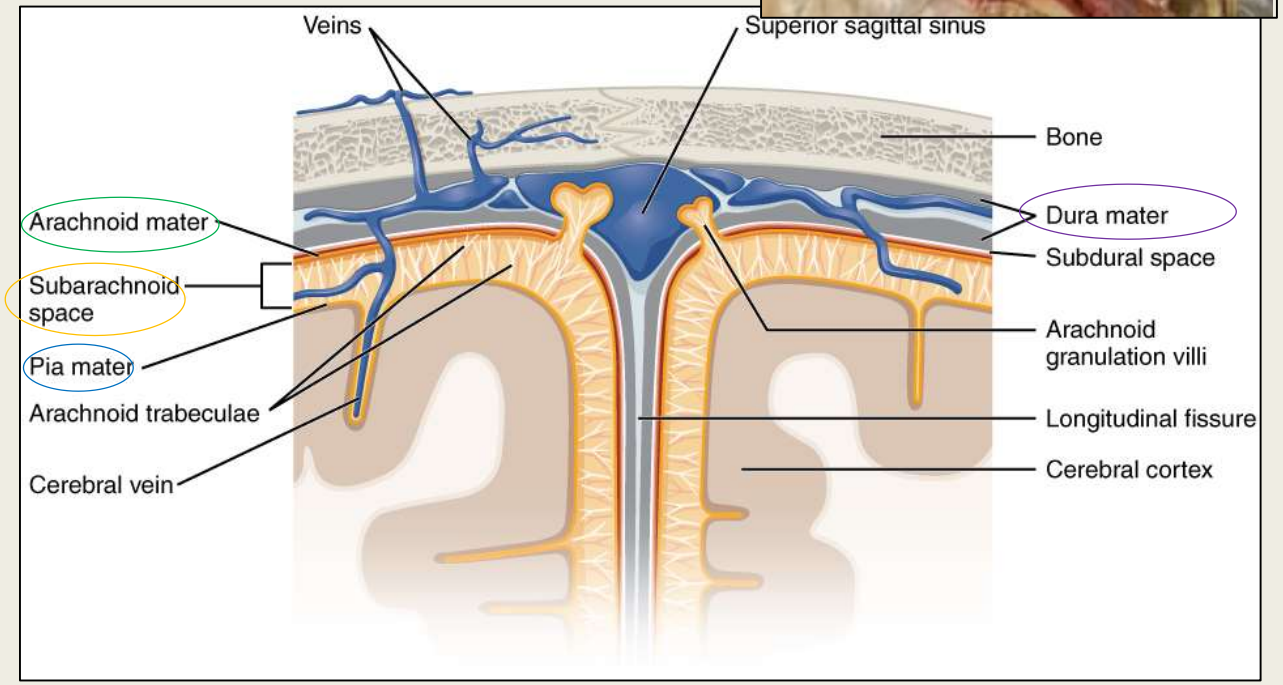


http://serendipstudio.org/

CNS Anatomy: Meninges

protect the central nervous system

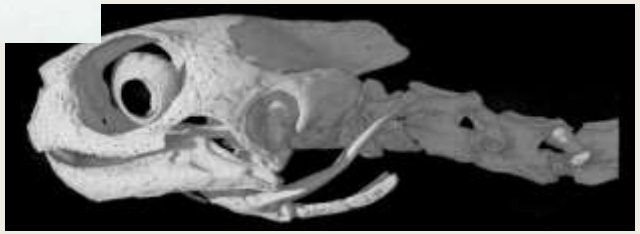
- ***dura mater*** outer meningeal layer
- ***arachnoid*** middle meningeal layer
- ***pia mater*** inner meningeal layer
- ***subdural space*** potential space between dura mater and arachnoid layers
- ***subarachnoid space*** real space between arachnoid and pia mater; contains CSF



https://commons.wikimedia.org/w/index.php?curid=30147959

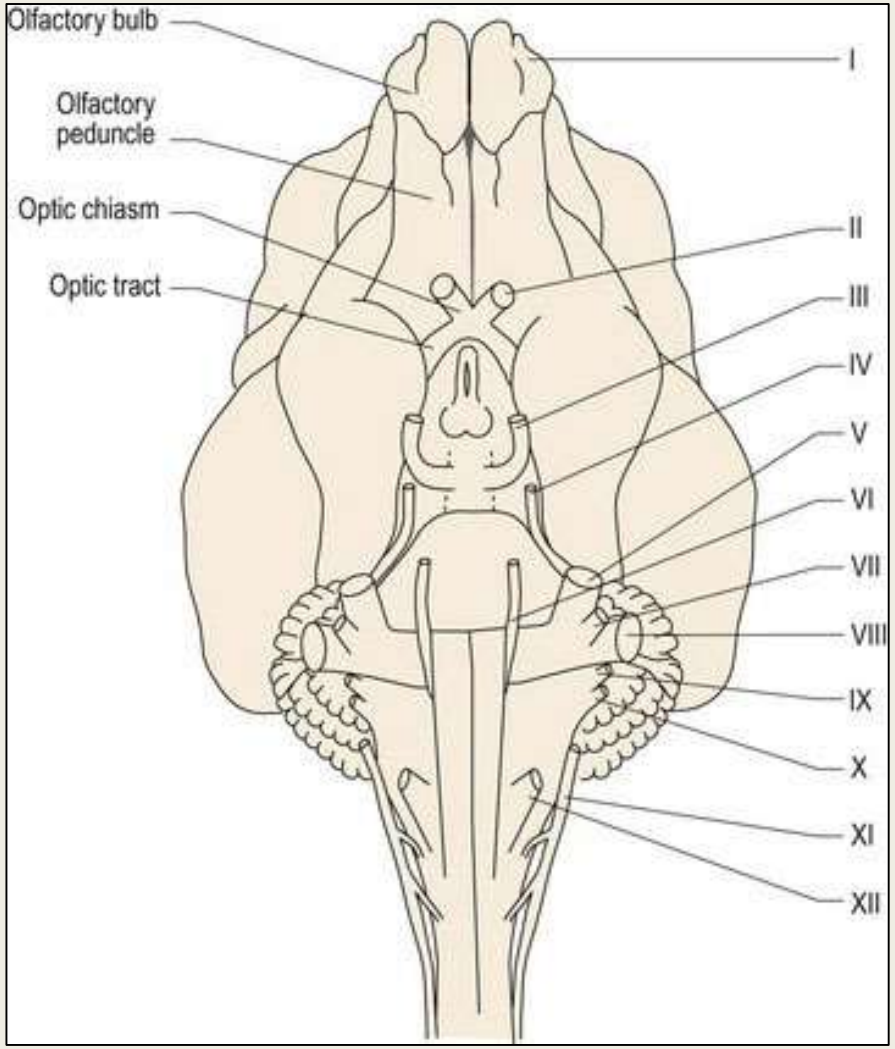
CNS Anatomy: Skulls

- Species & Age variation
  - *younger soft vs confining*
  - *cushioning*
  - *shape*
- Eyes
  - *size*
  - *amt of protection*



Cranial Nerves

- CN I and II = Forebrain
- CNN III and IV = Midbrain
- CN V to XII = mid and caudal brainstem



veteriankey.com/

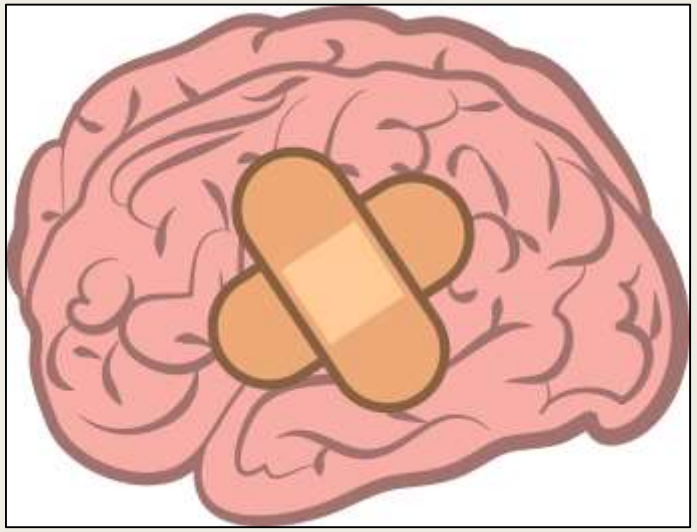
CNS Injury—**How**
Head Trauma (TBI)

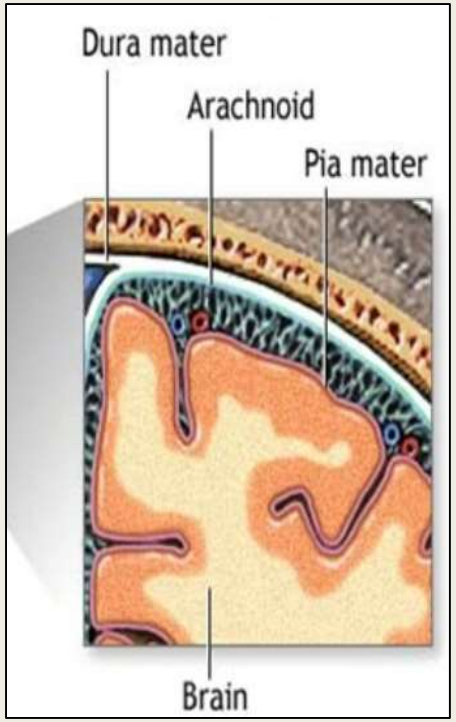
- Skull fractures
  - *Not that common in live animals*
  - *Require extreme blow*

  or penetrating injury
  - *Poor prognosis*
  - *Damage to underlying vessels and tissue*

Blunt Head Trauma

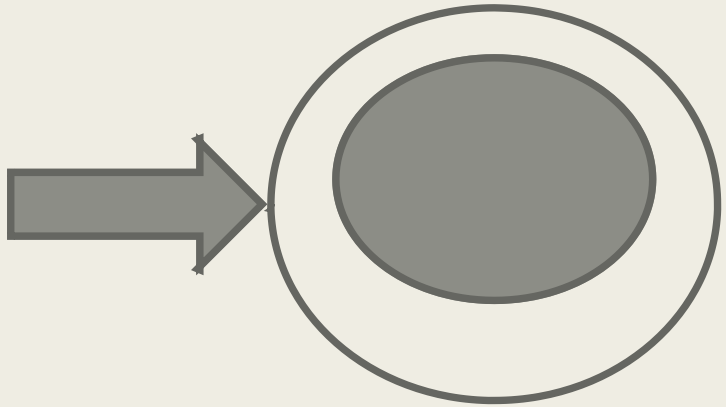
- Hit by vehicle
- Hit by golf ball (bat, etc.)
- Flew into window
- Fell from nest
- Dropped by raptor





Head Trauma (TBI)

- Often no external lesions
- Brain moves with impact
  - *Coup*



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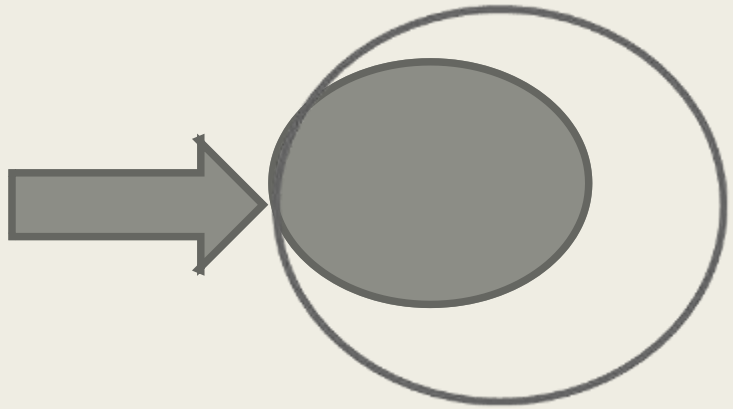
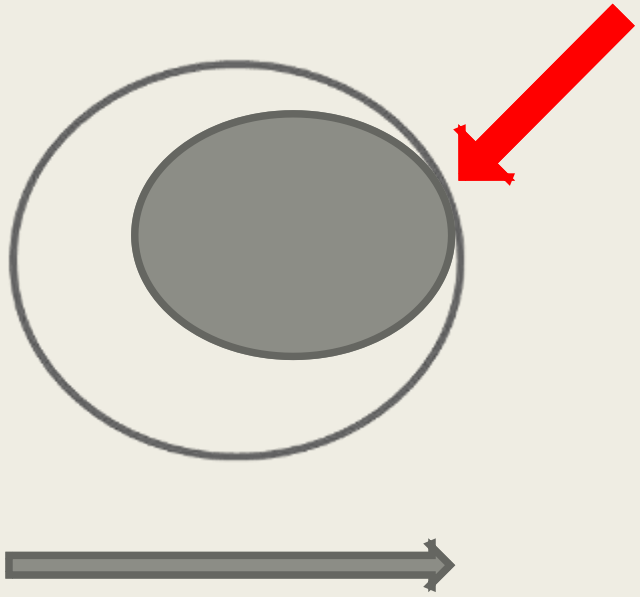


Head Trauma (TBI)

- Often no external lesions
- Brain moves with impact
  - *Coup*
  - *Contrecoup*
- Swelling to brain
  - *Vasodilation*
  - *Increased ICP*
  - *Response is ↓ blood flow → hypoxia*



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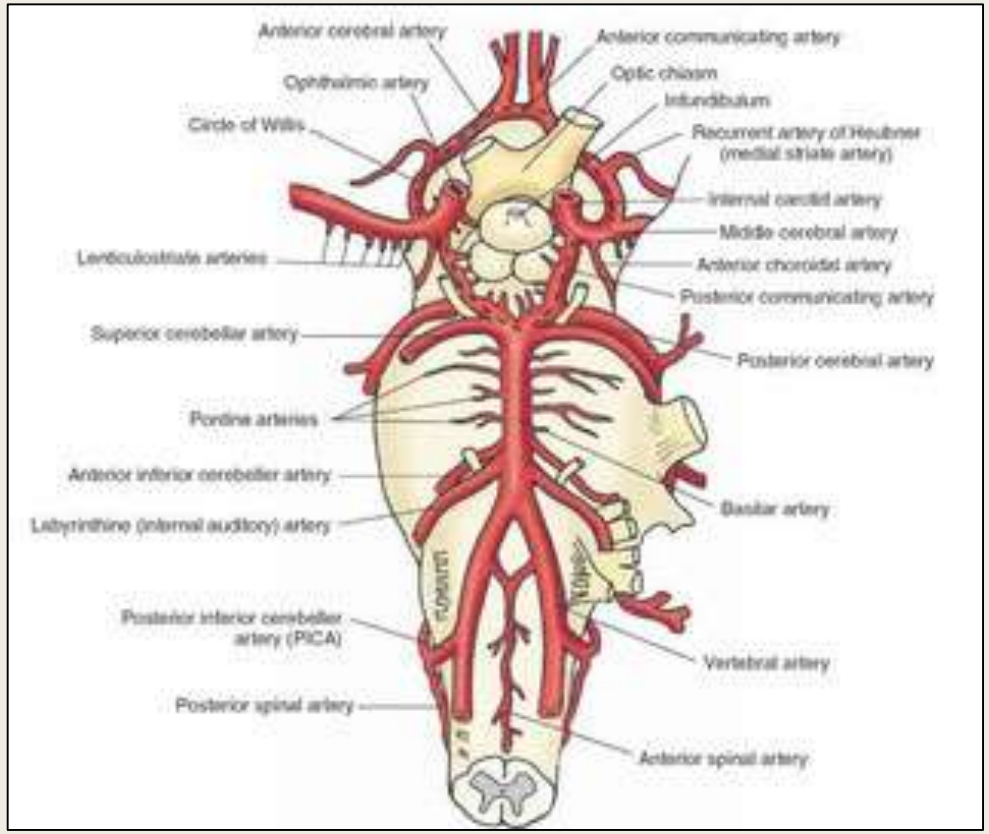
Blunt Head Trauma

- Skull doesn’t fracture
- Brain sloshes around in skull…

Head Trauma (TBI) with hemorrhage

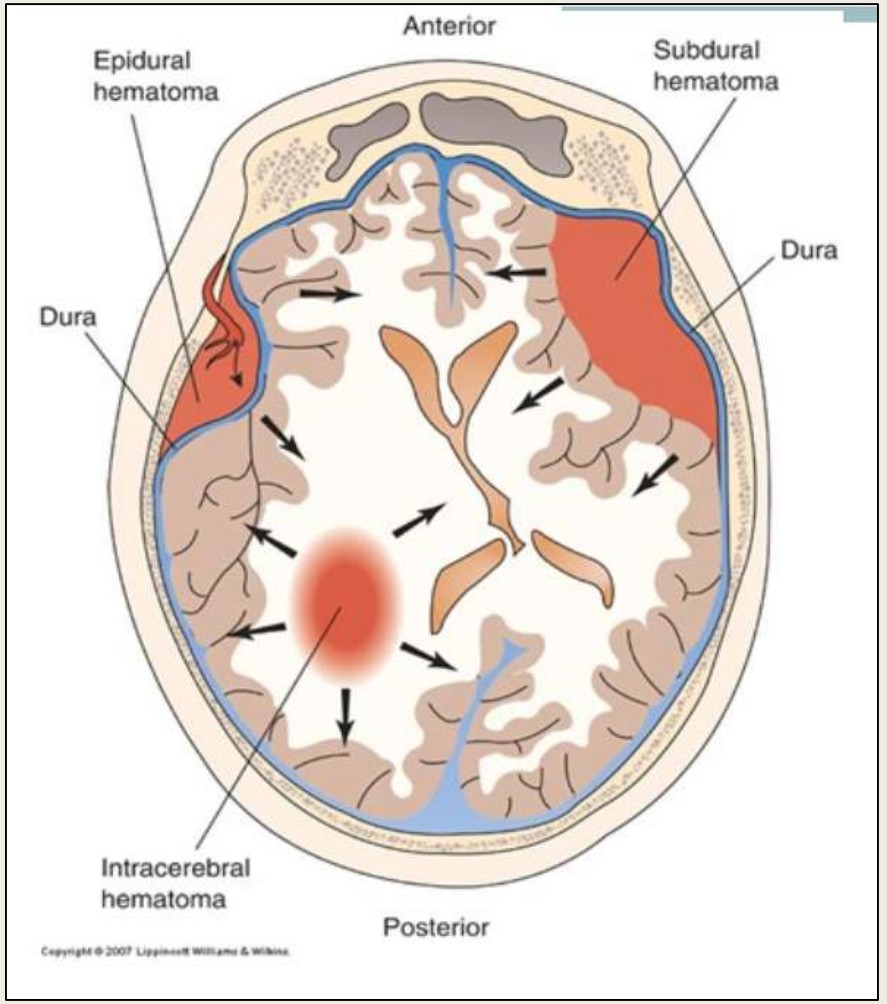
- Vessels rupture from shear, stretch, and or laceration
- Brain normally receives 20% of blood coming from heart→Hypoxia
- Inflammation→↑BP, electrolyte imbalances, etc.



www.Neurologyneeds.com

Intracranial Hemorrhage

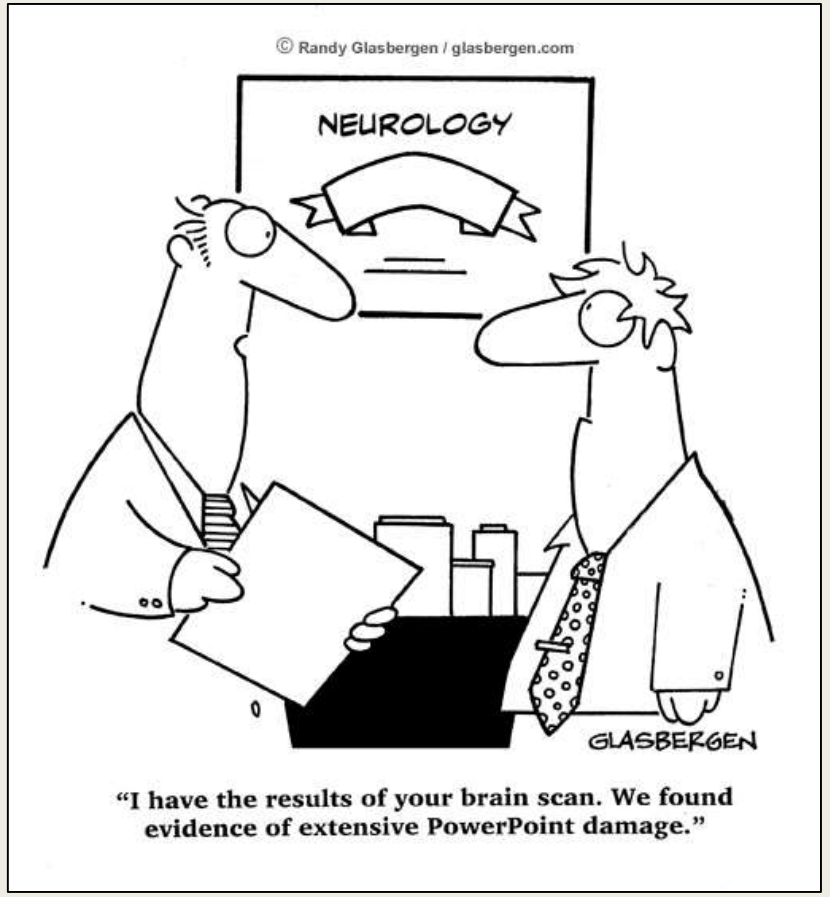
- Confined space
- Rupture blood vessel
- Focal loss of oxygen
- Regional pressure/inflammation
- Spreads and worsens
  - *i.e., delayed effects*



Assessing Neurologic Signs: Catch-22

Needs to be done:

1) after shock (if present) has been addressed
2) before pain meds



Treat shock but no pain meds…

Goals:

- Maximize O_2 to the brain
- Reduce intracranial pressure
  - *Prop up head--30° slant*
  - *Rest—minimize movement*
- Fluids?
  - *Colloids IV if available*
  - *Hypertonic saline*
    - 7.5% at 4ml/kg slow

Treating Head Trauma after the exam

- Continue rest & oxygen
- Consider fluids & dextrose
- *Analgesic/Anti-inflammatories after exam*
- *Timolol to ↓ IOP & to ↓ BP*

Assessing Head Trauma: Neuro Exam

- Mentation
- Eyes (brainstem)
- Gate (motor activity)
- Posture (spinal trauma)

Check for other injuries

- Animal Triage Trauma Score
- Higher ATT scores (more severe injuries) = less likely to survive + more intensive care required

www.k9tecc.org/assets/Animal_Trauma_Triage_Score.pdf

Animal Trauma Triage (ATT) Score

Perfusion	
MM pink/moist, CRT 2 sec, T ≥ 100F, strong or bounding femoral pulse quality	0
MM hyperemic **or** pale pink, MM tacky, T ≥ 100F, CRT 0–2 sec, fair femoral pulses	1
MM very pale pink & tacky, CRT 2–3 sec, T < 100F, detectable but poor pulses	2
MM gray/blue/white, CRT > 3 sec, T < 100F, non-palpable femoral pulses	3
Cardiac	
HR canine: 60–140 bpm feline: 120–200 bpm, normal sinus rhythm	0
HR canine: 140–180 bpm feline: 200–260 bpm, NSR or VPC < 20/min	1
HR canine: > 180 bpm feline: > 260 bpm, consistent arrhythmia	2
HR canine: < 60 bpm feline: ≤ 120 bpm, erratic arrhythmia	3
Respiratory	
Regular resp rate with no stridor, no abdominal component to resp	0
Mild inc resp rate and eff, ± abd comp, mild upper airway sounds	1
Mod inc resp rate and effort, some abd comp, elbow abduct, mod inc upper airway	2
Marked resp effort **or** gasping/agonal resp, little/no air passage	3
Eye/Muscle/Integument	
Abrasion/laceration - none or partial thickness. Eye: no fluorescein uptake.	0
Abrasion/laceration - full thickness. **No** deep tissue involved. Eye - corneal lac not perf.	1
Abrasion/laceration - full thickness, deep tissue involved, art/nerve/muscle intact. Eye: corneal perforation, punctured globe or proptosis.	2
Penetration of abdomen/thorax. Abrasion/laceration full thickness, deep tissue invol, artery/nerve/muscle compromised.	3
Skeletal	
Wt bearing 3 or 4 limbs. No palpable fx/jt laxity.	0
Closed limb fx/rib fx or any mandibular fx. Single jt laxity/lux (including SI). Pelvic fx with unilateral intact SI -ilium-acetabulum. Single limb open/closed fx at or below carpus/tarsus.	1
Multiple grade 1 conditions, single long bone open fx above carpus/tarsus with cortical bone preserved. Non-mandibular skull fx.	2
Vertebral body fx/luxation except coccygeal, multiple long bone open fx above tarsus/carpus, single long bone open fx above tarsus/carpus with loss of cortical bone.	3
Neurologic	
Central: consciousness: alert to sl dull, interest in surrounding. Periph: normal spinal reflexes; purposeful movement and nociception in all limbs.	0
Central: dull/depressed/withdrawn. Periph: abn spinal reflexes with purposeful movement and nociception intact in all 4 limbs.	1
Central: unconscious, responds to noxious stimuli. Periph: absent purposeful movement with intact nociception in 2 or more limbs **or** nociception absent in 1 limb, decr anal or tail tone.	2
Central: nonresponsive to all stimuli, refractory seizures. Periph: absent nociception in 2 or more limbs, absent tail or perianal nociception.	3

Score 0–3 (3 = most severe) for each of the above 6 categories. Add all scores together for total ATT Score.
"Each point increase in the ATT score resulted in a 2.3–2.6 times decreased likelihood of survival."
Journal of Veterinary Emergency and Critical Care. 2007;4(2):77–83

Modified Glasgow Coma Scale

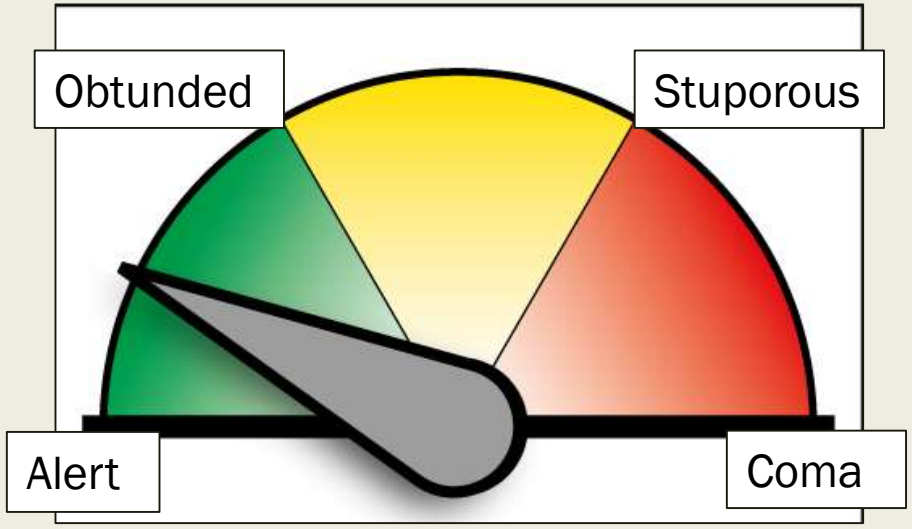
- Adapted from Human to Dog/Cat evaluations
- Lower numbers = poorer prognosis
- Evaluates
  - *Mentation (conscious)*
  - *Eyes (brainstem)*
  - *Gate (motor activity)*

Modified Glasgow Coma Scale		
		SCORE
Motor Activity	Normal gait, normal spinal reflexes	6
	Hemiparensis, tetraparesis, or decerebrate rigidity	5
	Recumbent, intermittent extensor rigidity	4
	Recumbent, constant extensor rigidity	3
	Recumbent, constant extensor rigidity with opisthotonus	2
	Recumbent, hypotonia of muscles, depressed or absent spinal reflexes	1
Brainstem Reflexes	Normal PLR and oculocephalic reflexes	6
	Slow PLR and normal to reduced oculocephalic reflexes	5
	Bilateral unresponsive miosis with normal to reduced oculocephalic reflexes	4
	Pinpoint pupils with reduced to absent oculocephalic reflexes	3
	Unilateral, unresponsive mydriasis with reduced to absent oculocephalic reflexes	2
	Bilateral, unresponsive mydriasis with reduced to absent oculocephalic reflexes	1
Level of Consciousness	Occasional periods of alertness and responsive to environment	6
	Depression or delirium, capable of responding but response may be inappropriate	5
	Semicomatose, responsive to visual stimuli	4
	Semicomatose, responsive to auditory stimuli	3
	Semicomatose, responsive only to repeated noxious stimuli	2
	Comatose, unresponsive to repeated noxious stimuli	1
MCGS Score		SCORE
	3-8	grave
	9-14	guarded
	15-18	good

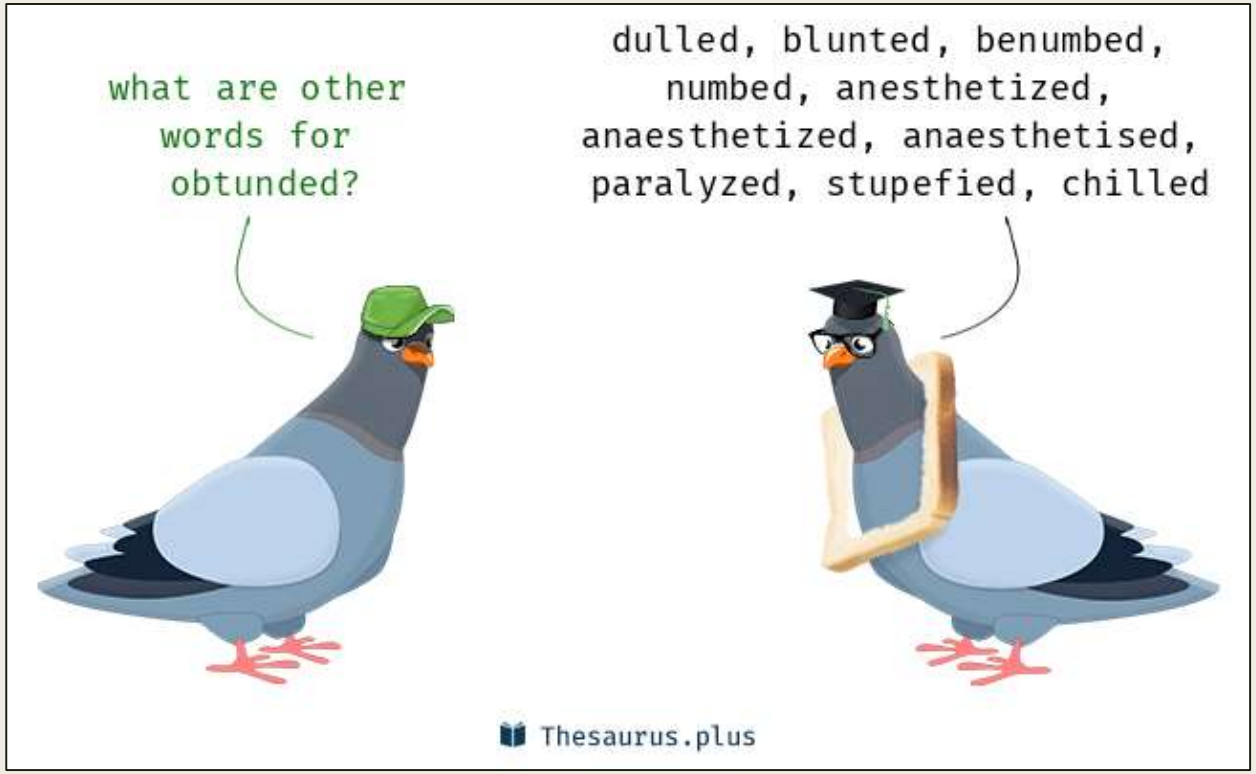
http://bvns.net/wp-content/uploads/2016/09/Neurotransmitter-2.0-MGCS-final.pdf

Evaluating Mentation

--Brainstem & Cerebral cortex

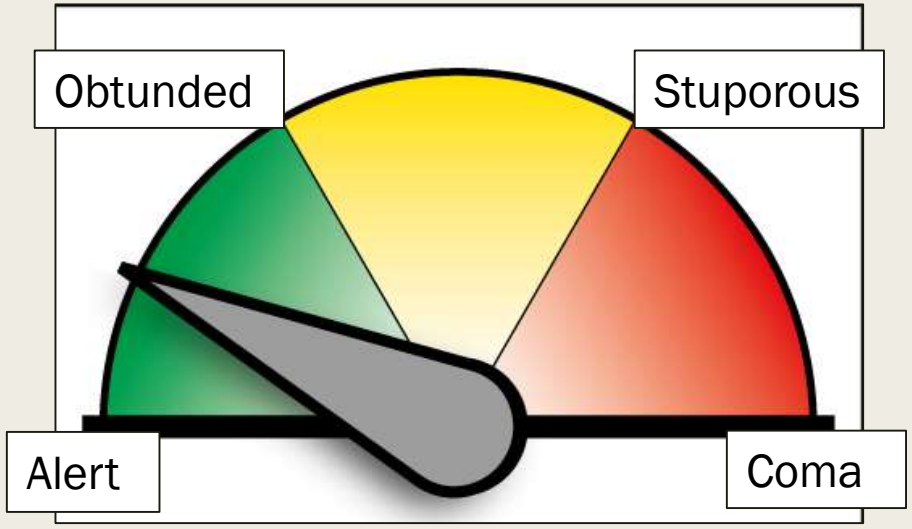


- Alert
- Obtunded
  - *Responsive to stimuli, but may be inappropriate*
- Stuporous
  - *Responsive only to noxious stimuli*
- Unconscious/Comatose
  - *Non-responsive*



Evaluating Mentation

--Brainstem & Cerebral cortex



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Modified Glasgow Coma Scale

Level of Consciousness

6. Occasional periods of alertness and responsive to environment
5. Depression or delirium, capable of responding but response may be inappropriate
4. Semicomatose, responsive to visual stimuli
3. Semicomatose, responsive to auditory stimuli
2. Semicomatose, responsive only to repeated noxious stimuli
1. Comatose, unresponsive to repeated noxious stimuli

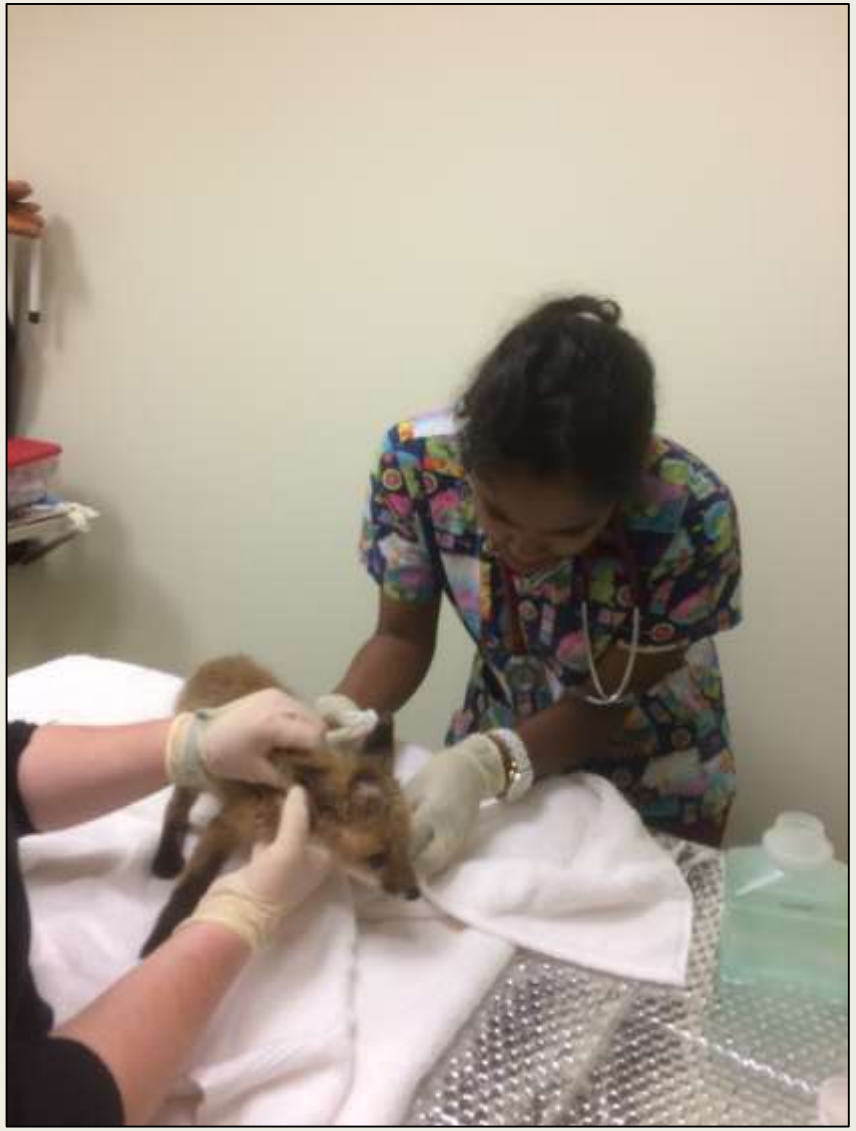
Red-tailed Hawk

Blue Jay

- Opisthotonus (rigid neck)
  - *Damage to cerebellum or brain stem*
  - *Poor prognosis*

Neuro Exam: Palpation

- Check for asymmetry, tenderness, and tone
- Palpate skull & vertebral column for deviations and pain
  - *do not to apply too much pressure!*
- Unilateral muscle atrophy may indicate a neurogenic loss
- Wet with small amt alcohol



Evaluating Eyes

- Windows to the soul, and the brain….

Evaluating Eyes: Pupils

- Size
  - *Miosis* = constricted
  - *Mydriasis* = dilated
  - *Anisocoria* = unequal pupils

Evaluating Eyes: Pupils

- Size
- Shape
  - *Eye trauma (lens)*
  - *↑IOP*
- Response to light

Evaluating Eyes: Pupils

- Size
- Shape
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Evaluating Eyes: Pupils

- Size
- Shape
  - *Eye trauma (lens)*
  - *↑IOP*
  - *Species variation*
- Response to light

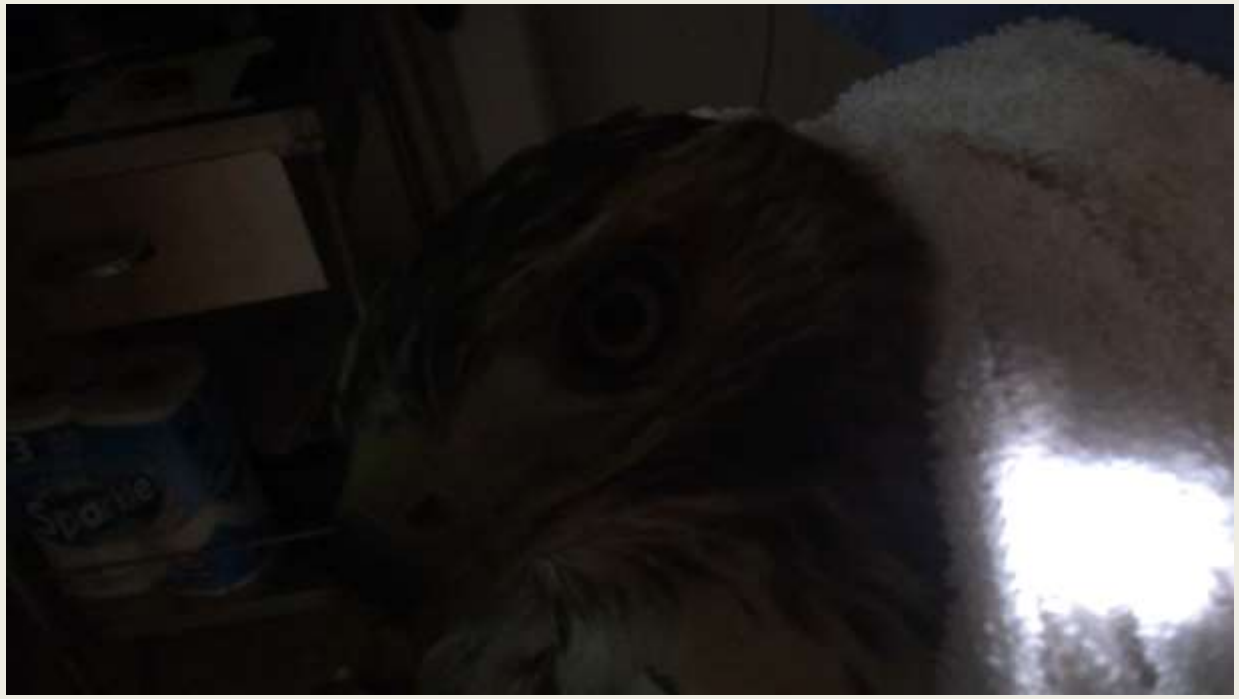
Evaluating Eyes: Pupils

- Size
- Shape
- Response to light (PLR)
  - *Should constrict quickly*
  - *May be subtle (esp. birds & herps)*
  - *Slow response w/ ↑IOP or TBI*
  - *No response = severe injury*
  - *CN II, III & thalmus (forebrain)*

Hippus (pupillary athetosis)

= spasmodic, rhythmic, but regular dilating and contracting pupillary movements

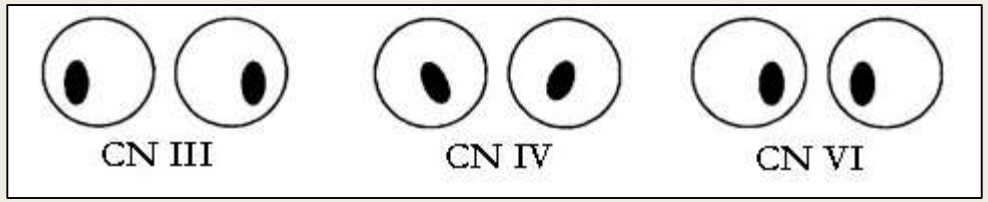
- Some may be normal
- Pathologic hippus
  - *Some poisonings*
  - *Trauma to midbrain*
    - Guarded to poor prognosis



Evaluating Eyes: Strabismus

- Abnormal eye position
  - *Ventrolateral*
  - *Dorsolateral*
  - *Medial*
- Abnormal eye position

- Cranial Nerve Affected
  - *CN III*
  - *CN IV*
  - *CN VI*
- Midbrain lesion



Prognosis

- Good
- Fair
- Guarded
- Poor
- Grave

- Safe bet
- Worth a try (>50/50)
- Not betting anything I value
- Need to evaluate whole patient & resources
- It’s called grave for a reason

Evaluating Eyes: Pupils

Interpretation of pupil size / PLR

Pupil size	PLR	Level of the lesion	Prognosis
Midposition	WNL		Good
Bilateral miosis	↓ to none		Variable
Unilateral mydriasis	↓ to none	Cranial nerve III	Guarded to poor
Unilateral mydriasis + ventrolateral strabismus	↓ to none	Midbrain	Guarded to poor
Midposition	None	Pons / Medulla	Poor to grave
Bilateral mydriasis	↓ to none		Poor to grave

Adapted from Fletcher DJ and Syring RS in *Small Animal Critical Care Medicine* 2009

Evaluating Eyes Unconscious Patient: Nystagmus (Oculocephalic Reflex)

- Size
- Equality
- Shape
- Response to light
- Response to position
  - *Unconscious patient*
  - *Turn head → eyes stay forward*
    = brainstem is intact
  - *Evaluates CN III, IV, VI & VIII*

- move the head from side to side in a horizontal plane and observe the resulting movement of the eyes
- in normal conscious animals, a physiological nystagmus will be induced, with the fast phase in the direction of head movement

Evaluating Eyes: MGCS

Brainstem Reflexes

6. Normal pupillary light reflexes and oculocephalic reflexes
5. Slow pupillary light reflexes and normal to reduced oculocephalic reflexes
4. Bilateral unresponsive miosis with normal to reduced oculocephalic reflexes
3. Pinpoint pupils with reduced to absent oculocephalic reflexes
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Review Quiz: Terminology

Term

- Hippus
- Nystagmus
- Strabismus
- Anisocoria

What & Where

- Spasm: Midbrain
- Eye movement: Hindbrain
- Abn. Position: Midbrain
- Abn. Pupil Sizes: Fore to Midbrain

Evaluating Eyes: Menace Response

- Cover one eye and motion to other eye
  - *Normal = blink or retraction*
  - *Abnormal = Damage to*
    - CNs II +/or V +/- VII
    - Visual pathways
    - Cerebellum

Photo source: Clinician's Brief

Evaluate Incisors in Rabbits and Rodents!

- Head/jaw impact may damage incisors
- Opposing incisors must be intact for release
- Rabbits, squirrels, muskrats, woodchucks, etc.
- And don’t forget ears…

Gate (motor activity)

Motor activity

6. Normal gait, normal spinal reflexes
5. Hemiparesis, tetraparesis, or decerebrate activity
4. Recumbent, intermittent extensor rigidity
3. Recumbent, constant extensor rigidity
2. Recumbent, constant extensor rigidity with opisthotonus
1. Recumbent, hypotonia of muscles, depressed or absent spinal reflexes

Seizures

Electrical Stimulation in Brain

- *Direct trauma*
- *Blood (Iron)*
- *Overstimulation*
- *Electrical disruption*

Treatment

- Safely control the animal
- Oxygen
- Sedative/calming agent
- Anti-inflammatory

Prognosis is poor w/repeated seizures

Birds

- Seizure Medications
  - *Midazolam 0.5 -1 mg/kg IM: Status*
  - *Keppra:*
    - 100 mg/kg IM: Status and maintenance (Schnellbacher 2014)
  - *Gabapentin:*
    - 10-15 mg/kg PO q8 (Baine 2015, Yaw 2015)
- Anti-nausea
  - *Cerenia 1mg/kg*
- Pain Meds
  - *Tramadol*
    - Columbiformes: 7.5mg/kg PO q8-12h (Black 2010)
    - Raptors:
      - *Eagles: 5mg/kg PO q12 (Souza 2013)*
      - *Red Tailed hawks: 11 mg/kg PO q12-24h (Souza 2011)*
  - *Gabapentin*
    - 10-15 mg/kg PO q8 (Baine 2015)
- Local Analgesics (skin wounds)
  - *Lidocaine: 2.2mg/kg max*

Small Mammals

- Pain Medications
  - *Tramadol*
    - 2-5 mg/kg PO q8 (Souza 2008, Valle 2000)
  - *Gabapentin:*
    - 5-10 mg/kg PO q8-12

- Seizure Medications
  - *Midazolam 0.5 – 1 mg/kg IM*
  - *Keppra :*
    - Status: up to 60 mg/kg
    - Maintenance: 20 mg/kg q8
  - *Gabapentin 10 mg/kg PO q8*

- Anti-nausea
  - *Cerenia 1mg/kg*

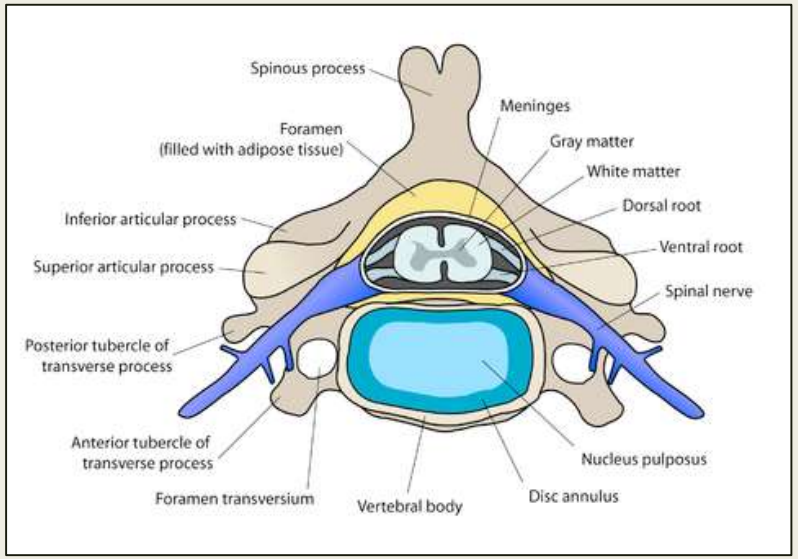
Reptiles

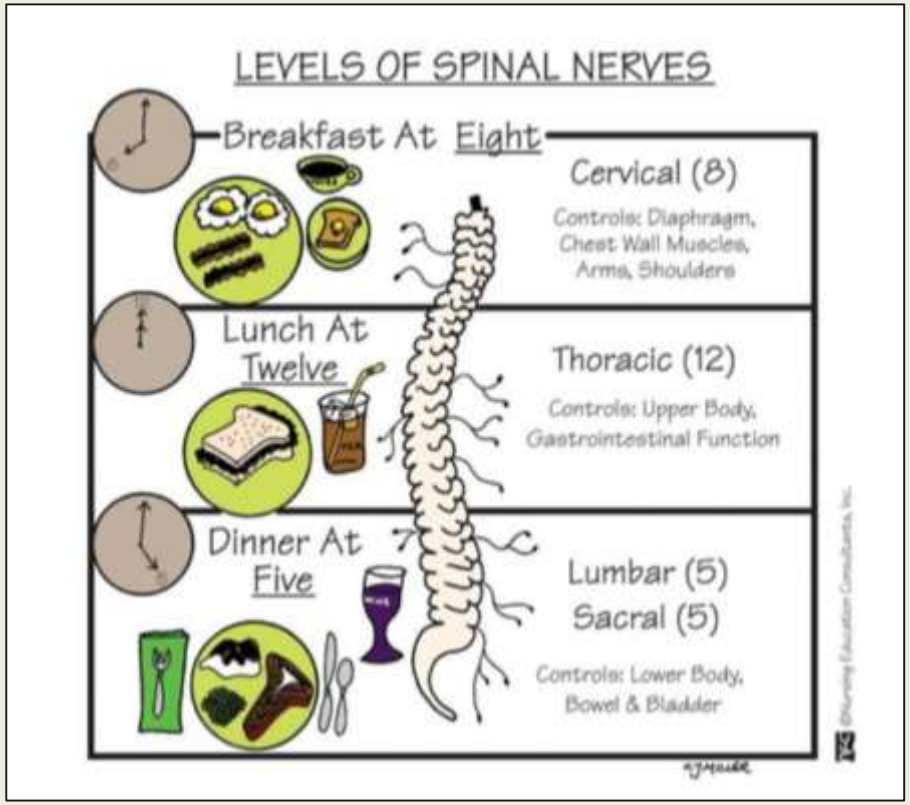
- Pain Medications
  - *Tramadol*
    - Turtles: 5 mg/kg IV/SQ q24-48 (Baker 2011)
    - Lizards: 2.5-5 mg/kg q12-24h
  - *Fentanyl Patches:*
    - Snakes: 12.5 mcg q7d in snakes <1.5kg (Darrow 2010)
      - *> 2kg: 25 mcg patch*
    - Lizards: 12.5 mcg patch <2 kgs (Gamble 2008)
      - *>2 kgs: 25 mcg patch*
  - *Meloxicam*
    - 0.2 mg/kg q24-48h
- Seizure Medications
  - *Midazolam 0.5 mg/kg IM*
  - *Confirm Ca/Mg status and supplement if needed*
- Anti-nausea
  - *Cerenia 1mg/kg*

Spinal Trauma

Clinical signs and damage depends on:

- Location of injury
- Extent of injury
  - *Compression*
  - *Inflammation*
  - *Transection*





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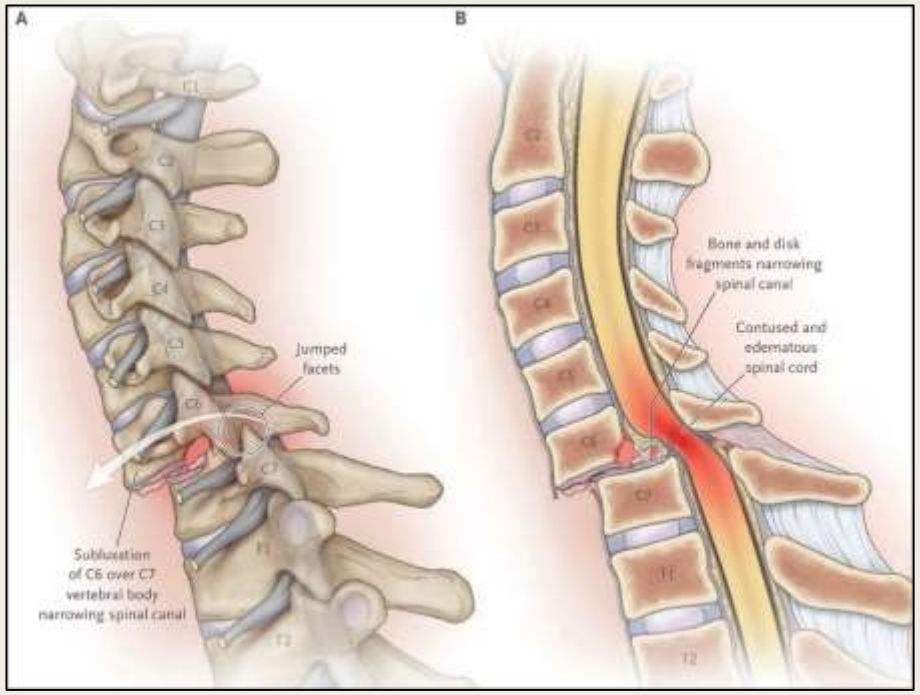
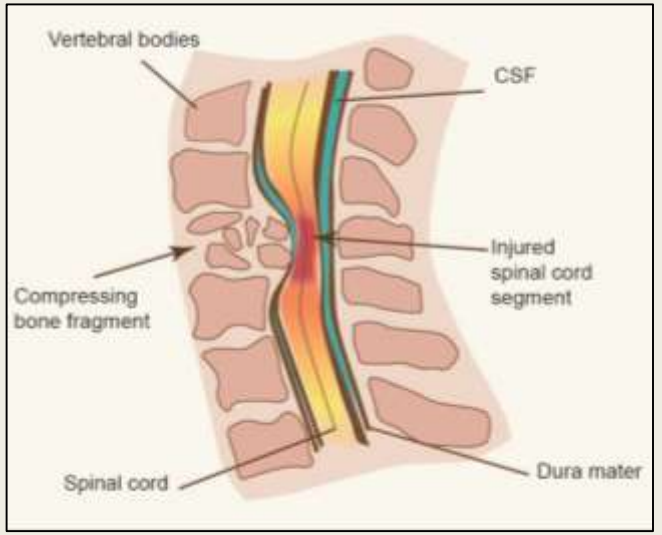
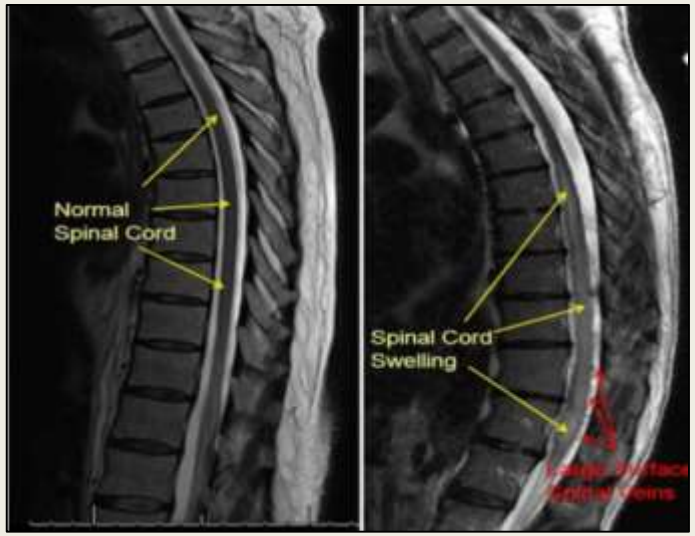


https://resident360.nejm.org



http://www.nrronline.org/



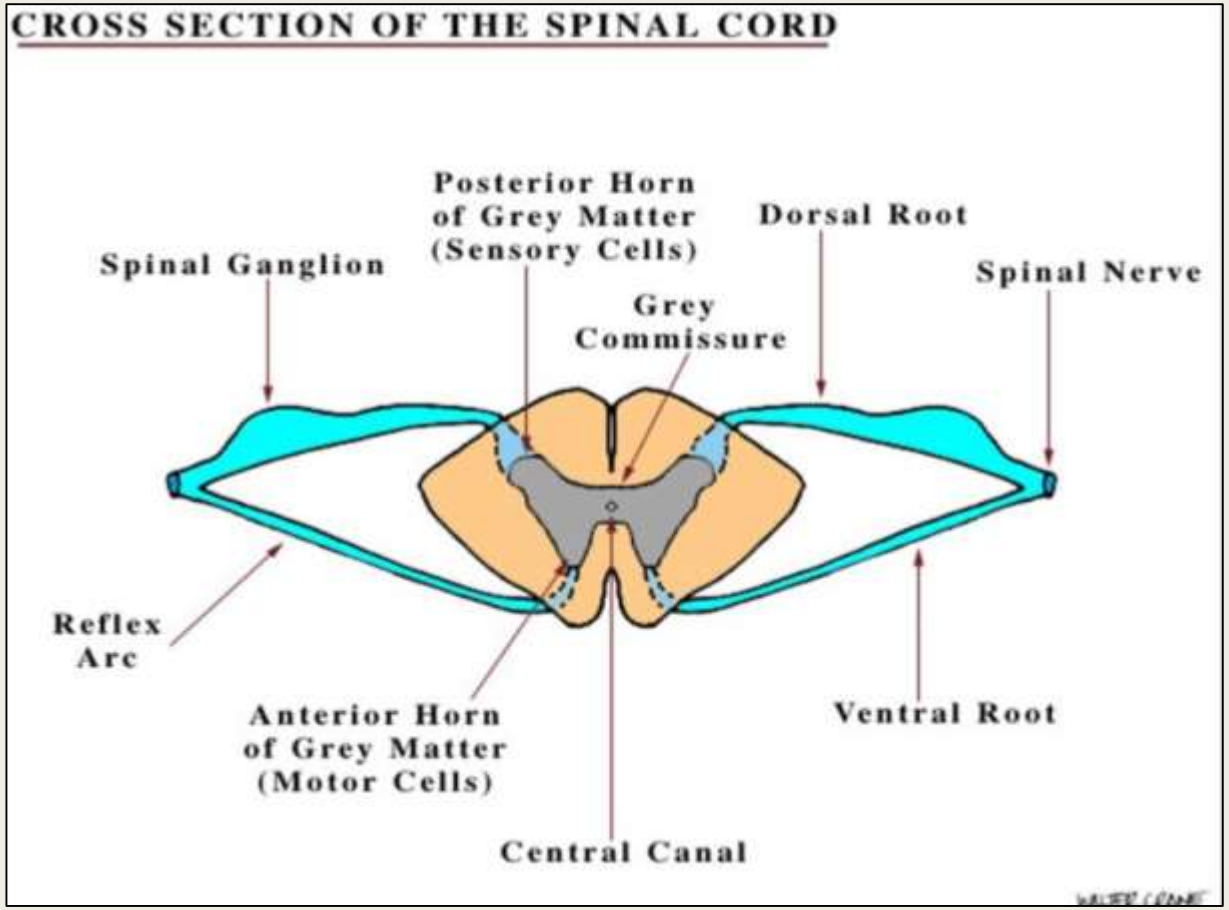
Assessing Spinal Trauma

Dorsal root = Sensory

- Injury—exaggerated response

Ventral root = Motor

- Injury—decreased or absent response



Reflexes to Assess

- Cloacal/Anal sphincter
- Leg Withdrawal
- Wing Withdrawal

- Touch
- Pinch

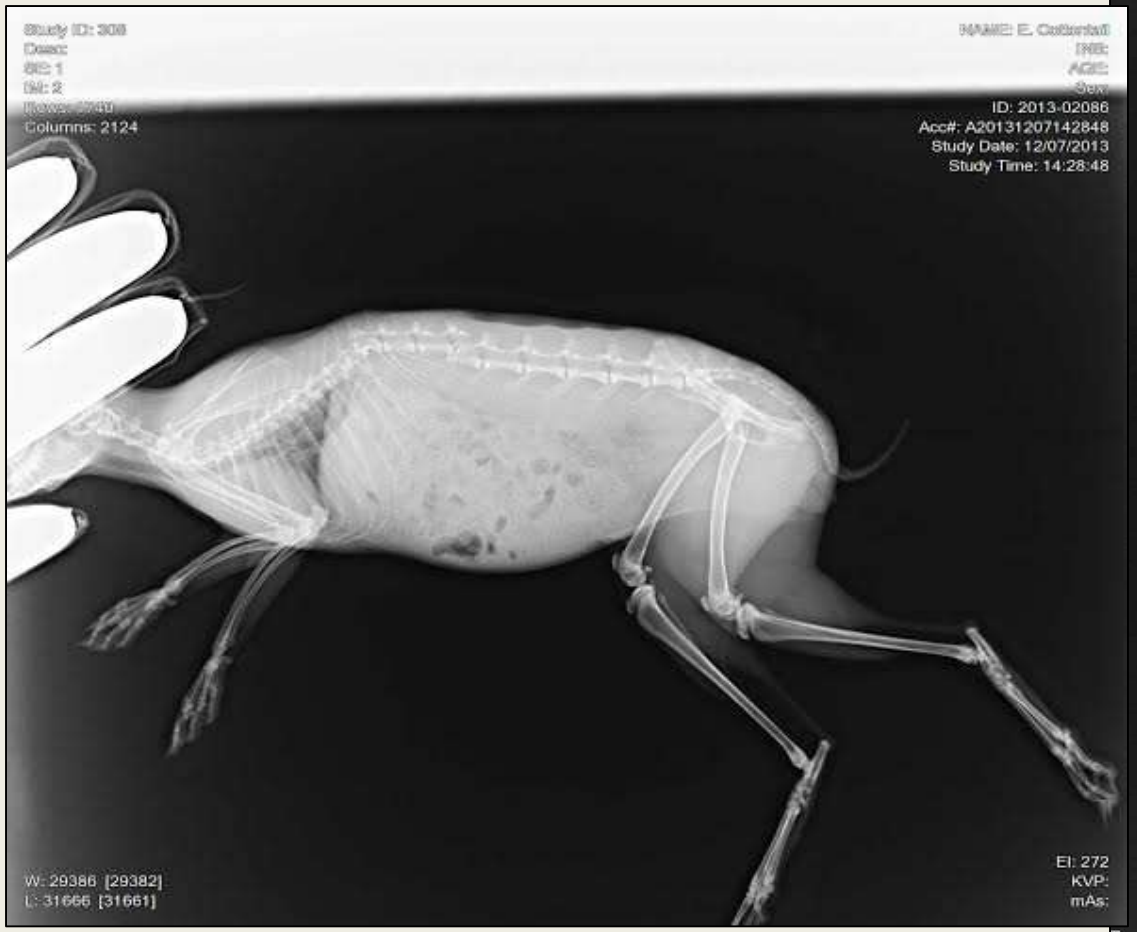
- Reflex = arc is intact
  - *May still have lesion*
- Reaction = spine is intact
- No response = spine injury

Spinal Trauma in Cottontails

- Most HBV rabbits with spinal fractures or luxations have them occur in the lumbar region
- LMN signs
  - *Hind leg paralysis*
  - *No cloacal tone*
  - *Distended urinary bladder*

Two Radiographs to Assess Spine

Two Radiographs



Spinal lesion treatment

- Most are not treatable
- If no fracture seen on radiograph AND has some cloacal tone, may be spinal swelling or hemorrhage around cord
  - *Anti-inflammatories to decrease swelling*
  - *Quiet to decrease stimuli*
  - *Sedatives to minimize movement*

Great Horned Owl 1

Great Horned Owl 2

(video courtesy Dr. Shary Parker Siksay)

Evaluating for Release

- Behavior
- Prey catching

QUESTIONS?