Clinical Neuroanatomy
Part I: Brain & Eyes

Introduction

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Clinical Neuroanatomy
Brain & Eyes

Objectives

• Develop a rational, systematic approach to localization in clinical neurology

• Identify the anatomical structures of the central nervous system in the Cerebral Hemispheres and structures involved in eye movements

• Recognize those areas of the Brain and eyes involved in the development of common symptoms of multiple sclerosis

Localization is based on Neuroanatomy

Neuroanatomical thinking:
picturing the structures as you perform the neurological exam
Localization Introduction

- The CNS neurological approach to localization
  - Take note of all symptoms and signs
  - Consider what system(s) or pathway(s) is(are) implicated
  - Decide the potential location of a lesion could be & the side of the lesion
  - Adding up this analysis for each S/S
    - "Where in the nervous system can each of these localizations overlap?"
    - One lesion vs. 2 or more lesions!

Localization Shortcuts

- Findings of sensory loss rule out muscle disease & disorders of the neuromuscular junction

- Visual acuity changes due to neurological ds localized to structures above the brainstem that transmit info from the retina to the occipital cortex/visual imagery

- Seizures without other deficits localized to the cortex or subcortical structures in the thalamus

- Deficits of cognition without disturbances of consciousness or attention localize above the brainstem
Clinical Pearls

- FACE involvement Contralateral or Ipsilateral to weakness or numbness localize to BS or brain/cortex

- Unilateral symptoms – brain Bilateral symptoms – spinal cord

- CNS lesion – signs of asymmetric UMN dysfunction - Hyperreflexia & increased tone

Localization in Neurology

- The principal of "garbage in-garbage out" : if you fail to identify the clinical signs correctly, then you will be unable to identify where the problem is!

- Clues frequently come from each of the various systems such as cranial nerves, motor and sensory, so that the localization of the lesion may be confirmed by examining each system!
8 Levels of Localization in the CNS

1) The cortex - motor & sensory
2) The subcortical WM
3) The brain stem - midbrain, pons, medulla; the thalamus / Basal ganglia
4) The spinal cord
5) The spinal roots
6) The peripheral nerves
7) The neuromuscular junction
8) The muscle

An example of localization in neurology

A preview of clinical localization...

Slides: Stephen Krieger, Mount Sinai School of Medicine. Images: Sourced from Google.
An example of localization

Slides: Stephen Krieger, Mount Sinai School of Medicine. Images: Sourced from Google.
An example of localization in neurology
Answer the Questions?

• Based on the anatomic profile you have constructed, you should be able to construct an hypothesis about likely etiology (or etiologies). There are always exceptions, but generally...

  ▪ Correct localization
  ▪ Diagnosis
  ▪ Plan

Localization: Why bother?

• Offer a differential diagnosis
• Gives an indication of a potential cause
• Allows better selection of imaging & other diagnostic tests
• Directs for appropriate treatments
• Gives an indication of prognosis
Localization in MS

• Precise localization is crucial, for example, in:
  – Distinguishing between a true exacerbation and a pseudoexacerbation (heat, fever, symptom reactivation)
  – Correlating clinical findings with MRI changes
  – Distinguishing between physiologic and psychologic symptoms/signs
  – Distinguishing between MS attacks and other problems in MS patients (strokes, disc disease, etc)

Brain Localization Summary

• This process of localization is important in neurology because it enables us to narrow the differential diagnosis of a problem, leading to more expedient, effective, and efficient management of patients with neurological diseases!
Clinical Neuroanatomy Overview
for the MS clinician

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CMSC 2016

Overview

- Approach to localization in clinical neurology
- Cerebral signs
  - “The Eyes Have it”
- Brainstem syndromes
- Spinal cord syndromes
  and
- One bonus localizing sign

Slides: Stephen Krieger, Mount Sinai School of Medicine. Images: Sourced from Google.
3-D, neuroanatomical thinking: picturing the structures as you perform the neurological exam

Slides: Stephen Krieger, Mount Sinai School of Medicine. Images: Sourced from Google.

The Nervous System: overview

Brain
- Brainstem/Cerebellum → nerves to the face

Cervical Spinal Cord

Brachial Plexus → nerves to the arm

Thoracic Spinal Cord

Lumbosacral Nerve Roots

Lumbosacral Plexus → nerves to the leg
Approach to Localization

- Within the CNS: Streets and Avenues: Identifying the intersection
  - Avenues: long tracts and pathways
    - Sensory: Pain/Temp vs. Proprioception/Vibration
    - Motor: Descending pyramidal tracts
    - Coordination: pathways to and from the Cerebellum
  - Streets: horizontal sections/ exiting pathways
    - Cerebral: cortical functions; homunculus
    - Brainstem: exiting cranial nerves define level
    - Cord: exiting roots (dermatomes) define level

- Neighborhood Signs: looking for dysfunction in what's nearby
Approach to Localization

- Localization principles: Dividing up the map
  - Front to Back:
    - Anterior → Motor;
    - Posterior → Sensory
  - Left to Right:
    - Crossed Sides (Left Hemisphere → Right body)
  - Bottom to Top
    - Lumbar → Thoracic Spine → Cervical Spine → Brain
      - ?Leg involvement
      - ?Arm/Hand involvement
      - ?Facial involvement

Slides: Stephen Krieger, Mount Sinai School of Medicine. Images: Sourced from Google.

Planes of Section: terminology

(B) Coronal Sagittal Horizontal
Cerebral Signs

- Cerebral Cortex: the outermost surface

1) Corpus Callosum: crossing fibers

Slides: Stephen Krieger, Mount Sinai School of Medicine. Images: Sourced from Google.

Cerebral Signs

- Cortical Sensory and Motor homunculus

Sensory: postcentral gyrus   Motor: precentral gyrus

Slides: Stephen Krieger, Mount Sinai School of Medicine. Images: Sourced from Google.
Cerebral Signs

- Looking for Neighborhood Signs in Cortex, face & hand are together

Sensory: postcentral gyrus  Motor: precentral gyrus

Slides: Stephen Krieger, Mount Sinai School of Medicine. Images: Sourced from Google.

Cerebral Signs

- Homuncular representation.

Slides: Stephen Krieger, Mount Sinai School of Medicine. Images: Sourced from Google.
Primary cortices are made of cells dedicated to a particular basic function.

Slides: Stephen Krieger, Mount Sinai School of Medicine. Images: Sourced from Google.
Cerebral Signs

- Focal dysfunction localizable to Cerebrum
  - If lesion is at cortical level, can look for signs of focal cortical dysfunction
    - Subtle errors in Mental Status testing
    - Street level = cortex

- Aphasias
- Apraxias
- Neglect/Extinction
- Frontal Lobe Dysfunction:
  - 3 Behavioral syndromes
- Affect
  - Belle Indifference
  - Pseudobulbar Affect

Slides: Stephen Krieger, Mount Sinai School of Medicine. Images: Sourced from Google.
Cerebral Signs

- **Aphasia**: Focal disturbance of language
  - Dominant Hemisphere (usually L) –
    - most L handed are still L hemisphere dominant.
  - 2 basic forms:
    - **Motor/Expressive Aphasia** (Broca’s): Frontal
    - **Sensory/Receptive Aphasia** (Wernicke’s): Posterior

Cerebral Signs

- **Apraxia**: Focal disturbance of planning/doing
  - Non Dominant Hemisphere (usually R) –
  - Definition:
    - inability to perform an act despite intact pathways
    - “Dressing apraxia”
    - On exam: “brush your teeth”, “comb your hair”
  - Distinguish from Dementia
Cerebral Signs

- **Sensory Neglect:** Focal disturbance of sensory integration
  - Non Dominant Hemisphere (usually R) –
  - Definition:
    - inability to perceive a stimulus despite intact sensory pathways
    - “Left hemineglect”
  - On exam: “double simultaneous stim”
    - visual, tactile extinction
    - Asterognosis, agraphesthesa
  - Distinguish from Dementia
Cerebral Signs

- **Frontal Lobe Dysfunction:**
  - 3 Behavioral Syndromes
    - Orbitofrontal: Disinhibited, lewd, loud
      - (See Mr. Gage, below)
    - Dorsolateral Prefrontal: poor planning, dysexecutive function (set shifting, Go/NoGo)
    - Ventromedial Frontal: Flattened affect; avolitional; lobotomized

- Belle Indifference – Classic for MS.
- Distinguish from: Dementia, Personality d/o.

The Eyes Have It

- Two ways MS generally affects the eyes:
  - Optic neuritis
  - Extra-ocular movement abnormalities
    - (Very few other conditions do both.)
The Eyes Have It

- Optic Neuritis: blurry vision, grayed out, central scotoma
  - Afferent Pupilary Defect (Marcus Gunn Pupil): *Input* lesion

*Note: Loss of Vision in both eyes: Bilateral ON (ADEM) or single lesion in optic chiasm (MS)*...

*Slides: Stephen Krieger, Mount Sinai School of Medicine. Images: Sourced from Google.*

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The Eyes Have It

- Extra-ocular movements: CN3, 4, and 6:

*Slides: Stephen Krieger, Mount Sinai School of Medicine. Images: Sourced from Google.*
The Eyes Have It

- Extra-ocular movement abnormalities I:
  - Unilateral: Single cranial nerve defects; Not usually within Brainstem.
    - CN6 lesion (Abducens): Ipsilat poor lateral gaze.

R CN6 lesion
Midline gaze and Rightward gaze, bottom

L CN3 lesion
L eye down & out with ptosis (All planes of gaze)

The Eyes Have It

- Extra-ocular movement abnormalities II:
- MS effects on lateral gaze:
  - Often Bilateral: Impairments of conjugate gaze
    - Localize to within the brainstem

Slides: Stephen Krieger, Mount Sinai School of Medicine. Images: Sourced from Google.
The Eyes Have It

- Conjugate eye movement abnormalities caused by MS:
  - Really, only Three Brainstem Lateral Gaze Syndromes
    - 1) MLF lesion: **INO (tug of war)**
    - 2) B/L MLF lesions: **b/l INO**
      - midline – unlike strokes, demyelination doesn’t respect the midline
    - 3) MLF + PPRF: **1 ½ syndrome**
  - Tectum: Upgaze/convergence center
    - upbeat nystagmus (always pathological)

Slides: Stephen Krieger, Mount Sinai School of Medicine. Images: Sourced from Google.

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The Eyes Have It

- Single MLF lesion: **INO (tug of war)**

The abducting eye’s nystagmus = tug of the opposite eye medially

Slides: Stephen Krieger, Mount Sinai School of Medicine. Images: Sourced from Google.
The Eyes Have It

- Bilat (midline) MLF lesion: **B/L INO**

And...When a bilat INO results in lateral deviation (skew) of eyes at rest, The result is a Wall-Eyed Bilateral INO = **WEBINO syndrome**

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VI. The Eyes Have It

- Single MLF + PPRF lesion
  
  1 ½ syndrome

And...Nucleus of CN6 and the PPRF right near the nucleus of CN7 in pons:
When lesion produces a 1 ½ syndrome + a 7th palsy = 8 ½ syndrome

Slides: Stephen Krieger, Mount Sinai School of Medicine. Images: Sourced from Google.
VI. The Eyes Have It

- Single MLF + PPRF lesion

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Clinical Neuroanatomy
Part II: Brainstem & Spinal Cord

Introduction

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The Spinal Cord

- Neurons connect CNS to the body
  - Ascending sensory
  - Descending motor
- Anterior cord
- Central cord
- Hemicord (Brown sequard)
- Posterior cord
- Conus medullaris
- Cauda Equina
Clinical Localization Shortcuts

- FACE involvement contralateral or ipsilateral to weakness or numbness localize to BS or brain/cortex
- Unilateral symptoms – brain  Bilateral symptoms – spinal cord
- CNS lesion – signs of asymmetric UMN dysfunction - Hyperreflexia & increased tone

Clinical Pearl: Cervical Spinal Cord

- The higher the spine lesion leading to below the level signs and symptoms
- C2-3 lesions innervate below and above the level of lesion / injury
- Ex. Lesion at C2-3 leads to numbness in the back of the head
Localization of S/S

• Is there disease in the nervous system?
• Is it in the brain/spinal cord or outside the CNS?
• Is it in both brain & spinal cord?
• Is it the peripheral nerves, the neuromuscular junction or the muscle?

Localization of S/S

• At what level(s)? Which side? R vs. L.
• cerebral hemispheric cortex/subcortical
• Brain stem: midbrain /pons /medulla
• cerebellum
• spinal cord
• nerve root
• peripheral nerve
• neuromuscular junction / muscle
Localization of S/S

- What longitudinal system(s) is (are) involved?
  - consciousness
  - language
  - vision
  - motor function
  - coordination
  - pain, temperature
  - proprioception, vibration

Types of Localization

- Single lesion theory: can all symptoms/signs be explained by one lesion?

- Types of Localization
  - Focal, Multifocal, or Diffuse
  - MS, at different points, can be all three. Exacerbations themselves can be focal or multifocal
An example of localization in neurology

A preview of clinical localization...
Right sided weakness & left facial

AN EXAMPLE OF LOCALIZATION IN NEUROLOGY

Slides: Stephen Krieger, Mount Sinai School of Medicine. Images: Sourced from Google.
AN EXAMPLE OF LOCALIZATION IN NEUROLOGY

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An example of localization

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An example of localization in neurology

Brain & Spinal Cord
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      - ?Arm/Hand involvement
      - ?Facial involvement

The Funnel

- Below the cortex: descending/ascending tracts from the cortex on out
- The Funnel: why lesions in Brainstem/Spinal Cord cause more symptoms than in cerebrum
Why the Brainstem Matters

- In addition to being densely packed with avenues to and from the body...

- Brainstem Nuclei and Cranial Nerves are responsible for the most vital functions of the organism:
  - Vision
  - Respiration
  - Articulation
  - Speaking
  - Swallowing

Brainstem Syndromes

- The Brainstem = The base of The Funnel.
- Intermediary between Brain and Spinal Cord organization
  - Same Rules of organization apply
    - ie, Anterior = Motor; Posterior = Sensory
  - Cranial Nerves define the level (the streets)

Slides: Stephen Krieger, Mount Sinai School of Medicine. Images: Sourced from Google.
Brainstem Syndromes:

- Crossed Signs

- Three Main Brainstem Divisions, and Twelve Cranial Nerves.
  - nerves exit ipsilateral to their symptoms

- Top to Bottom, divided up:
  - First 4; Middle 4; Inferior 4:
    - Midbrain: CN3
    - Pons: CN5, CN6, CN7
    - Medulla: CN9, CN11, CN12

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Classic Brainstem Syndrome #1

- Man presents with double vision and left sided weakness.
  - On exam, his right eye is deviated down and out
  - His right eye will not move medially and ptosis is present
  - He is weak on the left side, arm and leg
  - He cannot walk or lift his left arm

R eye down & out with ptosis
(All planes of gaze)
Classic Brainstem Syndrome #1

- Man presents with double vision and left sided weakness.

  The Avenue: Descending Motor

  The Street: CN III: Oculomotor Nerve
  - Medial Gaze
  - Ptosis

  MIDBRAIN

Weber Syndrome
Classic Brainstem Syndrome #2

- Man presents with right facial weakness and left sided weakness.
  - On exam, his right nasolabial fold is flat
  - He cannot move the corner of his right mouth he is drooling from the right side of this mouth
  - His speech is slurred
  - He is weak on the left side, arm and leg
  - He cannot walk or lift his left arm

Classic Brainstem Syndrome #2

- Man presents with right face and left body weakness.

The Avenue: The Street:

ANTEROIOR:
- Descending Motor

CN VII:
- Facial Nerve
- Facial Weakness

THE PONS
Classic Brainstem Syndrome #2

- Man presents with right face and left body weakness.
  - Motor signs: Anterior
  - Cranial Nerve VII: The Pons
  - Which side? The Right side.
    - Crossed Signs
    - Nerve is ipsilateral (right), weakness is contralateral (left body)

Classic Brainstem Syndrome #3

- Woman presents with slurred speech, imbalance, and numbness
  - What do you suppose the ER would think of a stumbling, drooling patient with slurred speech and no focal weakness?

  - On exam, her speech is dysarthric and she’s drooling
  - Her gag reflex is diminished on the right
  - Her right face is numb to pain and temperature
  - Her left body is numb to pain and temperature
  - She is imbalanced and clumsy
Classic Brainstem Syndrome #3

- Woman presents with slurred speech, imbalance, and numbness

The Avenue:

- Sensory signs: Posterior (no Motor findings!)
- Cranial Nerves IX, X, XI: The Medulla
- Which side? The Right side.
  - Crossed Signs: right facial numbness and depressed right gag
  - Nerves are ipsilateral (right), body numbness is contralateral (left)
  - Limb clumsiness is ataxia from the cerebellar connections

The Street:

- Dysarthria
- Dysphagia
- Gag reflex

MEDULLA

Wallenberg Syndrome
Classic Brainstem Syndrome #4

- Man collapses in the grocery store, unresponsive, gets intubated, brought to Emergency Dept.
  - On exam, he makes no attempt to speak or move
  - He follows no commands and doesn't track left or right with his eyes
  - His face is motionless
  - He does not withdraw any limb to painful stimuli
  - He does not improve.

- Weeks later he is transferred to a long-term care facility, where a therapist notes that he seems to blink his left eye to command.

Classic Brainstem Syndrome #4

- Man is quadriplegic, aphonic, no horizontal eye movement; blinking intact.

The Avenue:

- Problems Doing Everything

The Street:

- CN III is the Lowest nerve Still functioning Eyelid blinks.
- CN IV, V, VI, VII And everything Below are not.

ANTERIOR PONS TRANSECTED

Anterior: Descending Motor
Classic Brainstem Syndrome #4

- Man is quadriplegic, aphonic, no horizontal eye movement; blinking intact.
  - Motor signs: Anterior
  - Cranial Nerve III still functions; everything below does not: The Pons
  - Which side? BOTH SIDES – Bilateral transection at Pons

- “This neurological injury paralyzes all expression – by word or movement – yet leaves the patient in possession of full sentient consciousness.”
  - Plum and Posner, 1972

Locked-In Syndrome

Slides: Stephen Krieger, Mount Sinai School of Medicine. Images: Sourced from Google.
Locked-In Syndrome

Brain

Brainstem/Cerebellum → nerves to the face

Cervical Spinal Cord

Brachial Plexus → nerves to the arm

Thoracic Spinal Cord

Lumbosacral Nerve Roots

Lumbosacral Plexus → nerves to the leg

Quadriplegia (Christopher Reeve)

Locked-In Syndrome

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Brainstem/Cerebellum → nerves to the face

Cervical Spinal Cord

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Thoracic Spinal Cord

Lumbosacral Nerve Roots

Lumbosacral Plexus → nerves to the leg

Quadriplegia

And Facial Paralysis With Aphonia

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Brainstem Syndromes

- Cranial Nerves NOT usually involved in MS: (red flags for other etiologies)
  - CN1: olfactory (Dementias, degenerative dz)
  - CN4: downgaze (Meningeal processes)
  - CN8: hearing usually spared
    - Mitochondrial d/o ṭ, Vasculitis, Susac ṭ
    - Vestibular system, however, is often affected (Middle Cerebellar Peduncle)

Slides: Stephen Krieger, Mount Sinai School of Medicine. Images: Sourced from Google.
Brainstem Syndromes

- **Ataxia** is the overall posterior fossa localizer
  - Intention tremor; Dysmetria; Rebound; Titubation
- Cerebellum and its connections
- The Cerebellum as shock absorber
- Cerebellar homunculus: midline = trunk; lateral = limbs
- Cerebellar hemispheres are doublecrossed so Ipsilateral to body (unlike everything else in head)

![Cerebellar homunculus](image)

Slides: Stephen Krieger, Mount Sinai School of Medicine. Images: Sourced from Google.

Brainstem Syndromes

An example of Localization:

- **Case:** 34 year old man with headache, vertigo, clumsiness, and unsteady vision
- **Eye findings:** Extraocular motility was abnormal. The patient had conjugate eye movements. There was a jerk nystagmus with the fast phase down-going. The nystagmus was more prominent in down and lateral gaze, and dampened with up-gaze. Downward pursuit was abnormal.
- **Fundus examination:** Normal disc, macula, vessels OU
- **Visual fields:** normal
- **Neurologic Exam:** The neurologic examination was notable for restricted range of motion of the neck, a diffuse increase in muscle tone, decreased proprioception of hands and feet bilaterally, dysmetria of the left arm, positive Romberg sign, ataxic gait, abnormal tandem gait, hyperreflexia with bilateral upgoing toes and ankle clonus.

Slides: Stephen Krieger, Mount Sinai School of Medicine. Images: Sourced from Google.
Brainstem Syndromes

An example of Localization, summary:

- Systems involved:
  - Cranial nerves: Extraocular movements (nystagmus);
  - Motor (spasticity, hyperreflexia, upgoing toes);
  - Sensory (loss of proprioception, positive Romberg);
  - Cerebellar (dysmetria of left arm, ataxic gait)

- Focal, Multifocal, or Diffuse?

- Can one lesion explain all the symptoms/signs?
  - Where?

Slides: Stephen Krieger, Mount Sinai School of Medicine. Images: Sourced from Google.

Brainstem Syndromes

An example of Localization:

The Cervico-Medullary Junction: A Great Pretender.
(Bottom of the Funnel + Myriad Cranial Nerves + Cerebellar tracts Mimics multifocal disease, including MS.

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Spinal Cord Localization

Peripheral Sensory Distributions: Roots/Dermatomes and Nerves

- Tightly packed bundle of sensory and motor fibers: 
  - **No silent cord**

- Pattern recognition
  - Hallmark features of myelopathy:
    - Bilateral weakness/sensory loss
    - Bilateral UMN signs (Babinski, etc) and UMN weakness
    - Finger extensors, knee flexors, foot dorsiflexors
    - Bowel and bladder symptoms

- The “Street” is the sensory level at which the cord is affected

- Pattern recognition of 4 key cord syndromes…(to follow)

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Cord Localization

Anterior/Posterior distinction (Motor vs Sensory) is largely preserved
• Spinal roots: Sensory enters posteriorly, Motor exits anteriorly
• Anterior Horn cells = Ipsilateral Motor
• Posterior Column = Ipsilateral Touch, vibration, proprioceptive
• Spino-thalamic = Contralateral pain & temp (& anterior)

That rebellious spino-thalamic tract:
Sensory in the front, and
On the wrong side.

The posterior columns:
Ipsilateral, ascending vibration and proprioception.

Classic Cord Syndromes:
• 1. Anterior Cord Syndrome
• 2. Posterior Cord Syndrome
• 3. Lateral Cord Syndrome (Brown-Sequard)
• 4. Central Cord Syndrome
Cord Localization

• **Classic Cord Syndromes:**
  • 1. Anterior Cord Syndrome
    • Loss of ascending pain/temp.
    • Loss of descending motor.
    • Preserved vibration and proprioception.

    • Classic etiology:
      • Anterior Spinal Artery infarction (cord stroke)...also, post traumatic (whiplash, chiropractor, etc)

Slides: Stephen Krieger, Mount Sinai School of Medicine. Images: Sourced from Google.

Cord Localization

• **Classic Cord Syndromes:**
  • 2. Posterior Cord Syndrome
    • Preserved ascending pain/temp.
    • Preserved descending motor.
    • Loss of vibration and proprioception.

    • Classic etiologies:
      • Low B12, Syphilis, HIV myelopathy, Demyelinating dz
        Heavily myelinated pathways – JPS is fast; pain is slow

(One needs rapid streams of proprioceptive information in order to do anything.)

Slides: Stephen Krieger, Mount Sinai School of Medicine. Images: Sourced from Google.
Cord Localization

- **Classic Cord Syndromes:**
  - 2. Posterior Cord Syndrome

  Thoracic cord (1 posterior column)  Cervical cord (2 posterior columns)

  Slides: Stephen Krieger, Mount Sinai School of Medicine. Images: Sourced from Google.

Cord Localization

- **Classic Cord Syndromes:**
  - 3. Lateral Cord Syndrome (Brown-Sequard...one guy)
    - Loss of ipsilateral vibration and proprioception
    - Loss of ipsilateral motor
    - Loss of contralateral pain/temp

    - One leg is weak, the other one is numb (to pinprick)

    - Classic etiologies:
      - Trauma, tumor,
      - compression from dural space

  Slides: Stephen Krieger, Mount Sinai School of Medicine. Images: Sourced from Google.
Cord Localization

- **Classic Cord Syndromes:**
  - 4. Central Cord Syndrome
    - Loss of bilateral crossing pain and temperature fibers
    - Loss of bilateral motor
    - Cape-like distribution of numbness

- Classic etiologies:
  - Syringomyelia,
  - intrinsic cord tumor,
  - demyelinating dz

Slides: Stephen Krieger, Mount Sinai School of Medicine. Images: Sourced from Google.

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Cord Localization

- **Classic Cord Syndromes:**
  - 4. Central Cord Syndrome

[Syringomyelia and NMO/Devic images]

Slides: Stephen Krieger, Mount Sinai School of Medicine. Images: Sourced from Google.
Thank you!

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